MEMOIRS

OF THE

NATIONAL MUSEUM
MELBOURNE

No. 12

D. J. MAHONY, M.Sc.
DIRECTOR

PUBLISHED BY ORDER OF THE TRUSTEES

MELBOURNE
Brown, Prior, Anderson Pty. Ltd., 430 Little Bourke St., Melbourne, C.1

MARCH, 1941

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REVISION OF THE GENUS *EUASTACUS* (CRAYFISHES, FAMILY PARASTACIDAE), WITH NOTES ON THE DISTRIBUTION OF CERTAIN SPECIES.[1]

By Ellen Clark

Plates I-IX, Fig. 1.

Introduction.

In a previous paper (2) an attempt was made to clear up the synonymy of the Australian Parastacidae, but it was not possible to make a complete survey of the group as material from many districts was not available. Since that time, however, much material from localities not previously represented has been collected or received for identification. Special attention was given to obtaining specimens from New South Wales, the type locality of most species of the genus.

With the material now available it has been possible to make a complete revision of the genus *Euastacus*; this revision has resulted in several alterations in nomenclature, the reasons for which are explained below.

The full synonymy of each species is included with its description, and the distribution (as far as is known) is indicated. Since difficulties arose in finding suitable maps of Victoria to illustrate the distribution, two special maps (Plates VIII and IX) were compiled from data on plans prepared by the State Rivers and Water Supply Commission and maps issued by the Geological Survey.

Nomenclature.

Genus EUASTACUS Clark.

Euastacus Clark, Mem. Nat. Mus. Vict., x, 1936, p. 10.

Carapace spinous or tuberculate; cervical groove deeply impressed, rounded. Rostral carinae spinous or tuberculate. Abdomen spinous or tuberculate; first segment with lateral lobes large and rounded. Telson more or less completely divided by a transverse suture, membranous posteriorly. Stems of podobranchs each produced into a broad wing-like expansion, covered by numerous long setae, terminated by sharply recurved hooks.

Genotype: *Euastacus elongatus* Clark.

In the original description of the genus the genotype was

1. Results of work assisted by a grant from the Commonwealth Research and Endowment Fund.

stated to be *Astacus serratus* Shaw, the reasons for the alteration shown above are given on page 11.

Crayfishes of the genus *Euastacus* are characterized by their large size and the armature of spines and tubercles on the carapace, abdomen and legs. They have been found in most of the rivers of Victoria; in the south-east of South Australia; and in the coastwise rivers of New South Wales and Queensland as far north as Coen. One species, *Astacopsis australasiensis* (Milne-Edwards), was recorded in 1903 from Sorong in the north-west of New Guinea (27), but the genus has not otherwise been recorded from any locality outside the mainland of Australia.

Prior to 1936, eleven species of spiny-tailed crayfishes, now included in the genus *Euastacus,* had been described; these, with type locality and the date of description are:

Cancer serratus Shaw (28), New Holland, 1794.
Astacus australasiensis Milne-Edwards (20), New Holland (later given as Sydney), 1837.
Astacoides nobilis Dana (4), ? New South Wales, 1852.
Astacoides spinifer Heller (13), New Holland, 1865.
Astacus armatus von Martens (31), Murray River, Australia, 1866.
Astacopsis paramattensis Spence-Bate (30), Paramatta River, Sydney, Australia, 1888.
Astacopsis sydneyensis Spence-Bate (30), Sydney, Australia, 1888.
Astacopsis serratus var. *yarraensis* McCoy (18), Yarra River, Victoria, 1888.
Astacopsis serratus var. *hirsutus* McCulloch (19), Bellemore Falls, Kangaroo River, New South Wales, 1917.
Astacopsis kershawi Smith (29), Moe River, Victoria, 1912.
Astacopsis fleckeri Watson (33), Root's Creek, North Queensland, 1935.

Since these species were described, much doubt has been thrown on their identity and validity, most authors recognizing only one species, *Astacus serratus* (Shaw), as valid, while others included also *Astacoides nobilis* Dana.

In the following pages the history of each of the names is given; six of them are accepted as valid species, five are shown to be synonyms, and the two varieties are raised to full specific rank; with the addition of three new species described herein the genus now has a total of nine species.

Cancer serratus Shaw was described in 1794, and the description was accompanied by a large coloured figure. Since

that date, the name *serratus* has been applied by most authors to each of the various species of spiny crayfishes found in the rivers of eastern Australia.

In 1898 Faxon (7) pointed out that the name *Cancer serratus* was preoccupied, having been used by Forskal in 1775 for the crab now known as *Scylla serratus;* he reinstated Heller's name *Astacoides spinifer*. In the same paper he listed four of the other previously described forms, mentioning that he had not seen examples of them, but, from the descriptions and figures, he considered each of them, with the exception of *nobilis,* synonymous with *spinifer*.

McCoy (17), described and figured as *Astacoides serratus* (Shaw), the species found in the Murray River, and included as synonyms *spinifer* and *armatus*. In a later paper (18), he described as *Astacopsis serratus* var. *yarraensis* the form found in the Yarra and adjacent rivers.

Smith (29) included all described species under *serratus,* which he considered one large variable species, although he admitted that the various forms differed markedly from each other. In the same paper he described as *Astacopsis kershawi* the form found in the Moe River, Victoria; this name is shown herein to be synonymous with *nobilis*.

McCulloch (19) placed as one large variable species, *serratus*, all the crayfishes from the Murray River in Victoria, South Australia and New South Wales; the Yarra River, Victoria; from Gippsland, Victoria; from numerous localities in New South Wales; and from Stanthorpe, Queensland. He separated as a distinct variety *Astacopsis serratus* var. *hirsutus,* a very hairy form from the Kangaroo River, New South Wales.

In 1936 (2) in a revision of the Australian members of the family Parastacidae, the genus *Euastacus* was erected for the Australian species previously contained in the genus *Astacopsis*. In that paper the name *serratus* was assigned to the species found in the Murray River and its tributaries in Victoria, New South Wales and South Australia. This species was made the genotype of the new genus. At the same time, *hirsutus* was retained as a variety of *serratus,* and *yarraensis* was raised to full specific rank; *nobilis* was reinstated for the form found in the coastwise rivers in Victoria and New South Wales, with *kershawi* retained as a sub-species, inhabiting various coastwise rivers in Victoria.

Since the publication of that revision, extensive enquiries have been made into the range of the genus, and a considerable number of specimens from numerous localities have been

collected, or received from other collectors. In this way a comprehensive series of the genus has been accumulated from localities not previously represented in our collections. Particular attention was given to the Sydney district, since New South Wales is the type locality of seven of the species previously described.

Careful examination of the material revealed nine distinct species, each of which is described and figured in the following pages. Of these, six belong to known species and three are new. Three species came from Sydney and the surrounding districts; and as was to be expected, they are identical with the species described from this district early last century.

Concerning the three species from the Sydney district, the first is *nobilis* Dana, of which the majority of the specimens obtained are small, the largest of them measuring up to seven inches in length from rostrum to telson. These specimens agree in every way with specimens collected in various coastwise rivers in Victoria and New South Wales. The second is *hirsutus* McCulloch; comparison with other forms has warranted making it a full species in place of a variety. The third species is *serratus* Shaw; examination of the large series of fully grown specimens proves that *serratus* Shaw and *spinifer* Heller are synonymous, and since the name *serratus* is unique for the genus, it must be retained. Several small specimens six or seven inches long, are identical with the description and figure of *paramattensis* Spence-Bate, other specimens about two inches long are identical with the description and figure of *sydneyensis* Spence-Bate, proving that both *paramattensis* and *sydneyensis* are synonymous with *serratus*.

From this it is evident that there are at least three species of the genus found around Sydney; *serratus, nobilis* and *hirsutus*. The synonymy of each species is given above the description of the species concerned.

The history of the nomenclature of the species found in the Murray River and its tributaries is somewhat confusing. The earliest record of a crayfish from the Murray is by Gray (10) in 1845 when, in a paper dealing with specimens collected by Eyre, he referred to a large species found in the Murray River; he gave no description, but remarked that it was "of a size ranging to 4½ lbs., and quite equal in flavour to the finest lobster." The next record is by Blandowski (1) in 1858; during his tour of north-western Victoria he collected "a beautiful species of spined lobster, two other varieties of crawfish, and three kinds of shrimps—all found in the Murray River."

It was not until 1866 that the species was described by von Martens (31), from a single female 330 mm. long, and named *Astacus armatus*. In a later paper (32) he placed *armatus* with *spinifer* Heller as synonyms of *serratus* Shaw.

McCoy (16) referred to the species as *Astacoides serratus* and in a later paper (17) described in full detail and figured the species as *serratus,* and all following authors (with the exception of Faxon, who used *spinifera*) have referred to this species as *serratus*.

Comparison of a large series of specimens from the Murray River with a series from Sydney shows that *serratus* and the Murray River species are distinct; therefore von Martens' name *armatus* must be reinstated.

Examination of material from the Murray River system has revealed two distinct species; this fact was not recognized when my previous paper (2) was published. In that paper specimens from Echuca were accepted as typical, and were described and figured as *serratus* Shaw. These specimens, it has now been observed, agree in all characters with those found in the Goulburn River system and other southern tributaries of the Murray River, and in the Murray River itself from Echuca west to Swan Hill; but differ in several characters from those in the northern tributaries, in the southern tributaries east of Cobram, and in the Murray River itself east of Cobram and west of Swan Hill.

The most outstanding differences between the two species are the length of the outer antennae, and the shape of the great chelae. In his description, von Martens states that "the hands are exactly similar in size and in the shape of the teeth situated on the cutting edges," but he gives no indication of the size of the chelae or whether they are very slender or stout; nor does he give any indication as to the length of the antennae. As a result of these omissions, it is not possible to say which of the two species von Martens had before him. The habitat is given as Murray River, Australia.

Since either of the two species will fit von Martens' description, it has been considered wiser to give the name *armatus* to the northern species, as this is the one that has been taken by the majority of previous authors as typical of the Murray River form. The southern species is redescribed herein as *elongatus* sp. nov., based on the specimens from Echuca which were previously, but erroneously, identified as *serratus* Shaw. These are the specimens on which the genus *Euastacus* was founded; therefore the new species *elongatus* becomes the genotype of the genus *Euastacus*.

Systematic Descriptions

Key to species of *EUASTACUS* Clark.

Rostrum very long and broad, apex long and sharp, carinae with sharp spines.
Second antennae reaching to, or beyond, telson.
Great chelae long and slender .. .. ELONGATUS sp. nov.
Second antennae reaching third or fourth abdominal segment.
Great chelae long and very stout .. .. ARMATUS (von Martens)
Great chelae short and stout .. .. YARRAENSIS (McCoy)
Rostrum long and broad, apex short, carinae tuberculate or with blunt spines.
Two rows of short broad spines or tubercles on each branchiostegite; abdomen spinose .. .. SERRATUS (Shaw)
Carapace and abdomen without large spines or tubercles; entire animal densely hirsute .. .. HIRSUTUS (McCulloch)
Rostrum short and broad, apex blunt, carinae tuberculate.
Abdomen with several rows of small sharp spines on each segment SUTTONI sp. nov.
Abdomen without spines or tubercles except on lateral margins FLECKERI (Watson)
Abdomen with three rows of sharp spines and a large rounded ridge on dorsum of each segment .. .. NOBILIS (Dana)
Abdomen with two rows of spines and a flattened ridge on dorsum of each segment .. .. BISPINOSUS sp. nov.

Euastacus elongatus sp. nov.

Plate I.

Euastacus serratus (Shaw), Clark, Mem. Nat. Mus. Vict., x, 1936, p. 12, pl. 1, fig. 1; pl. 2, fig. 12; Victorian Year-Book, 1936-37, p. 34.

Length of average adult specimen 300 mm.

Rostrum very long and broad, reaching end of third segment of second antennae, apex long and sharp; lateral carinae obtuse, each with three or four sharp spines. A blunt, punctate carina ending in a small sharp spine at base of each carina, and a small sharp spine on a large rounded boss posterior-laterally to it.

Second antennae long and slender, reaching beyond end of telson. Squame smooth, inner lobe short and broad, terminal spine long, stout and sharp. Interantennal spine triangular, apex blunt, lateral margins serrated.

Carapace more than twice as long as broad, broader than high, longer than abdomen. Branchiostegites studded with numerous small tubercles, and several sharp spines in an irregular row on upper margin.

Abdomen spinose. First segment with a long stout sharp spine on each lateral lobe, a short stout blunt spine above each lateral spine. Second segment with two short slender sharp spines on each lateral margin; a long stout sharp spine and a large broad, forwardly directed, sharp spine above the lateral spines. Third segment with a slender sharp spine at each lateral margin; a long stout sharp spine, directed slightly forwards, above each of the lateral spines. Fourth and fifth segments each with a short slender sharp spine at each lateral margin; a short slender sharp spine, a long stout forwardly directed sharp spine, and a large broad forwardly directed sharp spine above each lateral spine. Sixth segment with a very short sharp spine near each lateral margin; a short sharp backwardly directed spine above each lateral spine.

Telson broad, slightly longer than broad, almost completely divided by a

transverse suture, with a spine on each lateral margin at suture and three or four small spines on surface; inner rami of uropods each with a spine on lateral margin near posterior margin, median carina feeble, ending in a sharp spine near posterior margin; outer rami of uropods each with numerous spines along the transverse suture, three small spines on outer lateral margin. Lobes at base of uropods without spines.

Sternal keel bluntly rounded between first and third pereopods, sharp below great chelae; first pair of lateral processes very small and sharp, second pair larger, third pair four times as large as first, rounded; posterior pair large, blunt, and deeply grooved; processes between fourth pereopods long and stout.

Great chelae slender, propodus two and one-half times as long as broad, upper margin with four sharp spines. Lower margin with two rows of large sharp spines posteriorly and a single row of smaller spines anteriorly, cutting edge with two large and several small tubercles, a few small tubercles on upper surface below base of dactylus; dactylus very long and stout, apex long and slender, several small tubercles on cutting edge; upper margin usually smooth or with one spine near base, two or three small sharp spines near apex. Carpus with two long sharp spines on upper margin, upper surface deeply grooved; merus with two large and five small sharp spines along upper margin.

Habitat.—Victoria: Echuca, Murray River (type locality) (Dr. W. J. Harris); Shepparton, Goulburn River (A. D. Butcher); Broken River (E. Clark); Ten Mile, Upper Goulburn River (E. Clark); Jamieson River (A. Hordern); Howqua River (E. Clark).

The extremely long second antennae and the slender chelae at once distinguish this species from any other known member of the genus. The specimens from the headwaters of the Goulburn River, Howqua and Jamieson Rivers, differ from the others only in having shorter antennae.

Euastacus armatus (von Martens).

Plate II.

Astacus armatus von Martens, Ann. Mag. Nat. Hist., ser. 3, xvii, 1866, p. 359.

Astacopsis spinifera (Heller), Faxon, Proc. U.S. Nat. Mus., xx, 1898, p. 670; Mem. Mus. Comp. Zool., xl, 1914, p. 402.

Astacus serratus Shaw, McCoy, Ann. Mag. Nat. Hist., ser. 3, xx, 1867, p. 189; von Martens, Monats. Akad. Wiss. Berlin, p. 615, 1868.

Astacoides serratus (Shaw), McCoy, Prodromus Zool. Vict., i, dec. ii, 1878, p. 17, pl. 15.

Astacopsis serratus (Shaw), Haswell, Cat. Austrl. Mus., Crust., 1882, p. 174; Ortmann, Proc. Amer. Philos. Soc., xli, p. 292, 1902; Smith, Proc. Zool. Soc. Lond., 1912, p. 157, pl. 16; McCulloch, Rec. Austrl. Mus. no. 11, 1917, p. 237; Hale, Handbook Crust. Sth. Australia, 1927, p. 75, fig. 6 and fig. 73.

Length of average adult specimen 300 mm.

Rostrum very long and broad, reaching beyond end of third segment of second antennae, apex long and sharp; lateral carinae obtuse, each with three or four sharp spines. A blunt, punctate carina ending in a small sharp spine at base of each carina, and a small sharp spine on a large rounded boss posterior-laterally to it.

Second antennae reaching fourth abdominal segment. Squame smooth, inner lobe very short and broad, terminal spine long and stout, sharp. Inter-antennal spine large, triangular, apex blunt, lateral margins serrated.

Carapace more than twice as long as broad, broader than high, longer than abdomen. Branchiostegites studded with numerous small tubercles; several sharp spines and a few large tubercles in irregular rows on upper margin.

Abdomen spinose. First segment with a long stout sharp spine on each lateral lobe, a short stout blunt spine above each lateral spine. Second segment with two short slender sharp spines on each lateral margin; a long sharp spine, very large at the base, and a short sharp spine very broad at the base, directed slightly forward, above the lateral spines. Third segment with a slender sharp spine at each lateral margin; a long sharp spine, very large at the base, and a short sharp spine, very large at the base, above each lateral spine. Fourth and fifth segments each with a long slender sharp spine at each lateral margin; a short broad sharp spine, a long sharp spine very broad at the base, and a short sharp spine very broad at the base, above each lateral spine. Sixth segment with a very short broad sharp spine near each lateral margin, a very short broad sharp spine above each lateral spine.

Telson broad, slightly longer than broad, almost completely divided by a transverse suture, with a spine on each lateral margin at suture, and three or four small spines on surface; inner rami of uropods each with a spine on lateral margin near posterior margin, two or three small sharp spines along outer lateral margin; outer rami of uropods each with numerous spines along the transverse suture, some examples with two or three small spines on outer lateral margin. Lobes at base of uropods without spines.

Sternal keel broadly rounded between first and third pereopods, sharp below great chelae; first pair of lateral processes very small and sharp, second pair larger, third pair four times as large as first, rounded; posterior pair large, blunt, and deeply grooved; processes between fourth pereopods long and stout.

Great chelae slender, propodus two and one-half times as long as broad, upper margin with four sharp spines, lower margin with two rows of large sharp spines posteriorly and a single row of smaller spines anteriorly, cutting edge with two large and several small tubercles, a few small tubercles on upper surface below base of dactylus; dactylus very stout, apex short and blunt, cutting edge with two large and several small tubercles, upper margin smooth, two or three small spines near apex. Carpus with two long sharp spines on upper margin, upper surface deeply grooved; merus with two large and five small sharp spines on upper margin.

Habitat.—Victoria: Wahgunyah, Murray River; Cobram, Murray River (P. J. O'Connor); King River (M. Webb); Ovens River, Wangaratta; Dondangadale River; Buffalo River (E. Clark); King River.

New South Wales: Hay, Murrumbidgee River (E. G. Austin); Narrandera, Murrumbidgee River (L. C. Haines); Deniliquin, Edward River.

South Australia: Blanche Town, Murray River (G. Brooks); Renmark, Murray River (M. Kennewell); Morgan, Murray River (Sth. Austrl. Mus.); Mannum, Murray River.

Readily separated from *E. elongatus* sp. nov., by the large stout chelae, the more spinose telson and uropods; and the structure and size of the abdominal spines; the larger and

more numerous spines on the pereopods, and by the shorter length of the second antennae.

This species has previously been figured by Hale (11), Huxley (14), McCoy (17), and Smith (29).

Euastacus yarraensis (McCoy).

Plate III.

Astacopsis serratus Shaw var. *yarraensis* McCoy, Prodromus Zool. Vict., ii, dec. 16, 1888, p. 225, pl. 16.

Astacopsis serratus (Shaw); Smith, Proc. Zool. Soc. Lond., 1912, p. 158, pl. xvii; McCulloch, Rec. Austrl. Mus., no. 11, 1917, p. 238.

Euastacus yarraensis (McCoy), Clark, Mem. Nat. Mus. Vict., x, 1936, p. 14, pl. II, fig. 13; Vict. Year-Book, 1936-37, p. 35.

Length of average adult specimen 300 mm.

Rostrum long and broad, reaching end of third segment of second antennae, apex long and sharp; lateral carinae obtuse, each with two or three small blunt spines. A blunt punctate carina, ending in a small blunt spine at base of each carina, and a small tubercle on a rounded boss posterior-laterally to it.

Second antennae reaching third or fourth abdominal segment. Squame smooth, inner lobe short and broad, terminal spine long stout and sharp. Interantennal spine triangular, apex blunt, lateral margins serrated.

Carapace twice as long as broad, broader than high, as long as abdomen. Branchiostegites studded with numerous small tubercles and an irregular row of several large tubercles on upper margin of each branchiostegite.

Abdomen spinose. First segment with a long slender sharp spine on each lateral lobe, and a small blunt spine above each lateral spine. Second segment with two or three long slender sharp spines along each lateral margin; a short sharp spine and a broad blunt spine above the lateral spines. Third, fourth and fifth segments each with a long slender sharp spine at each lateral margin; two long sharp spines and one short broad blunt spine above each lateral spine. Sixth segment with a slender sharp spine near each lateral margin, two small sharp spines above each lateral spine.

Telson longer than broad, almost completely divided by a transverse suture, a spine on each lateral margin at suture, and several short sharp spines on upper surface; inner rami of uropods each with a small sharp spine on outer lateral margin near posterior margin, median carina feeble, ending in a small sharp spine near posterior margin; outer rami each with a feeble longitudinal median carina, numerous sharp spines along the transverse suture, and two or three small spines on the outer lateral margin. Lobes at base of uropods without spines.

Sternal keel narrow, rather sharp; first three pairs of lateral processes small, blunt; fourth pair large, blunt, deeply grooved; processes between fourth pereopods long and stout.

Great chelae stout, propodus almost twice as long as broad, upper margin with four blunt spines, lower margin with two rows of short spines, cutting edge with two large tubercles, three or four small tubercles in a row on upper surface below cutting edge; dactylus stout, upper margin smooth, two or three small spines near apex, cutting edge with six or seven large tubercles. Carpus with one large and one small spine on upper margin; merus with two large and three small spines along upper margin.

Habitat.—Victoria: Yarra River (type locality); Kennedy Creek, tributary

of Curdies River, Cobden (W. A. Hall); Barwon River (W. Kershaw); Plenty River (S. A. Keartland); Watts River; Badger Creek; Bunyip River (W. Kershaw); Tarago River, near Warragul (Geo. F. Hill); Yea River (C. W. Brooks, Yea State School); King Parrot Creek; Acheron River (A. D. Butcher); Murrundindi River.

Readily separated from *E. armatus* (von Martens) by the armature of the carapace and abdomen, the form of the chelae, and the length of the antennae.

Euastacus serratus (Shaw).

Plate IV.

Cancer serratus Shaw, Zool. of New Holland, i, 1794, p. 21, pl. 8.

Potamobius serratus (Shaw), White, Proc. Zool. Soc. Lond., 1850, xviii, p. 95, pl. 15.

Astacopsis serratus (Shaw), Haswell, Cat. Austrl. Mus. Crust., 1882, p. 174; Smith, Proc. Zool. Soc. Lond., p. 157, 1912, pl. 16; McCulloch, Rec. Austrl. Mus., no. 11, p. 237, 1917.

Astacoides spinifer Heller, Reise Novara. Zool., ii, pt. 3, Crust., 1865, p. 102, pl. 9.

Astacopsis spinifer (Heller), Spence-Bate, "Challenger" Reports, xxiv, 1888, p. 195, pl. 28.

Astacopsis spinifera (Heller), Faxon, Proc. U.S. Nat. Mus., xx, 1898, p. 670; Faxon, Mem. Mus. Comp. Zool., xl, 1914, p. 402.

Astacus australasiensis Milne-Edwards, Hist. Nat. Crust., ii, p. 332, pl. 24, figs. 1-5, 1837; Audouin and Milne-Edwards, Arch. du Mus. d'Hist. Nat., ii, 1841, p. 36; Erichson, Arch. f. Naturg., xii, 1846, p. 94; Heller, Reise Novara, Crust., 1865, p. 100; von Martens, Monats. Akad. Wiss. Berlin, 1868, p. 618; Faxon, Proc. U.S. Nat. Mus., xx, 1898, p. 675.

Astacopsis paramattensis Spence-Bate, "Challenger" Reports, xxiv, 1888, p. 202, pl. 27; Faxon, Proc. U.S. Nat. Mus., xx, 1898, p. 675.

Astacopsis sydneyensis Spence-Bate, "Challenger" Reports, xxiv, 1888, p. 204, pl. 23; Faxon, Proc. U.S. Nat. Mus., xx, 1898, p. 675.

Length of largest specimen 222 mm.

Rostrum long and broad, reaching almost to end of third segment of second antennae, apex short and sharp, lateral carinae obtuse, each with a few small tubercles. A blunt, punctate carina ending in a small blunt spine at base of each carina, and a rounded boss posterior-laterally to it.

Second antennae slender, reaching to fourth abdominal segment. Squame smooth, inner lobe large and broad, terminal spine short and blunt. Inter-antennal spine long and slenderly triangular.

Carapace twice as long as broad, broader than high, as long as abdomen. Branchiostegites with numerous short, broad obtuse spines placed in two irregular rows below each branchio-cardiac groove; a row of large, slender and sharp spines continued to anterior of carapace below cervical groove, remainder of each branchiostegite studded with numerous small tubercles; several small sharp spines on anterior of carapace below rostrum; entire carapace densely punctate.

Sternal keel slender and sharp; a small, slender, sharp spine on keel below the third maxillipedes, great chelae, first and second pereopods; a slender sharp spine on keel between the spines of first and second pereopods. Lateral processes erect, upper margin sharp, processes between third pereopods

deeply grooved, flattened; processes between fourth pereopods short and stout.

Abdomen spinose. First segment with a long slender sharp spine on each lateral lobe, and a short broad obtuse spine above it. Second segment with three long spender sharp spines along each lateral margin; a long slender sharp spine above the lateral spines, and a short broad obtuse spine above it. Third, fourth and fifth segments each with a long slender sharp spine at each lateral margin; two rows of long slender sharp spines and a short broad obtuse spine above the lateral spines. Sixth segment with two long slender sharp spines near lateral margins, and several small sharp or obtuse spines on the upper surface.

Telson longer than broad, almost completely divided by a transverse suture; a spine on each lateral margin at suture, and one or more spines above it; numerous small sharp spines on calcareous portion of telson, three or four small sharp spines on membranous portion. Inner rami of uropods each with a spine on outer lateral margin near posterior margin, and two or three small sharp spines along the obsolete median carina, carina ending in a small sharp spine near posterior margin. Outer rami of uropods each with numerous small sharp spines along the transverse suture, numerous small sharp spines along the outer margin of each ramus. Lobes at base of uropods without spines.

Great chelae stout, propodus twice as long as broad, upper margin with four blunt spines, lower margin with a row of small sharp spines and a row of small blunt spines, apex sharp, cutting edge with two large tubercles, and several small tubercles; dactylus stout, three or four small spines along upper margin, apex sharp, cutting edge with numerous small tubercles. Carpus with two long sharp spines on upper margin, upper surface deeply grooved. Merus with two large and a few small sharp spines along the upper margin.

Habitat.—New South Wales: National Park (L. G. Russell); Sydney (E. M. Stephen); Baulkham Hills, near Parramatta (A. R. McCulloch); Yarramalong Mount, near Gosford (J. H. Wright and W. Barnes); Berowra Creek, near Hornsby; Ourimbah, near Gosford; Wahroonga; Fitzroy Falls, Kangaroo River (Melbourne Ward), caught in streams above the falls. *Blue Mountains (N.S.W.)*: Pools below Govett's Leap (M. Ward); Wall's Cave (E. Clark); Blackheath (E. Skehan).

The armature of the carapace and abdomen distinguishes this species from each of the other members of the genus, the very slender sharp spines on the abdomen being the main characteristic.

The specimens from the vicinity of Sydney are dark green or brownish green, but the specimens from the localities in the Blue Mountains are a vivid shade of red.

Euastacus hirsutus (McCulloch)

Astacopsis serratus var. *hirsutus* McCulloch, Records Austrl. Mus., no. 11, 1917, p. 238, pl. 43.

Euastacus serratus s.sp. *hirsutus* (McCulloch), Clark, Mem. Nat. Mus. Vict., x, 1936, p. 14, pl. ii, fig. 14.

Length of largest specimen 92 mm.

Rostrum slender, reaching to base of the third segment of first antennae, apex blunt; carinae blunt, with three or four small blunt spines along each

carina. A small blunt spine at base of each carina, with a small tubercle posterior-laterally to it.

Second antennae reaching to third abdominal segment. Squame smooth, sharply pointed, inner lobe broad. Interantennal spine long and slenderly triangular.

Carapace more than twice as long as broad, broader than high, much shorter than the abdomen. Branchiostegites and anterior of carapace studded with numerous small tubercles; areola and dorsum of carapace densely punctate. Entire carapace densely hirsute.

Abdomen hirsute. First segment without spines on lateral lobes. Second segment with small sharp spines along each lateral margin. Third, fourth and fifth segments each with a small sharp spine at each lateral margin. There are no other spines or tubercles on the abdomen. Entire abdomen densely hirsute.

Telson and uropods each densely hirsute.

Sternal keel broad and blunt; first pair of lateral processes small and sharp, second pair larger, blunt; posterior pair very large and blunt, deeply grooved; processes between fourth pereopods long and stout.

Great chelae stout; propodus three times as long as broad, apex sharp, upper margin with five or six blunt spines, lower margin with two rows of small tubercles, cutting edge with one large and three or four small tubercles, upper surface minutely tuberculate. Dactylus long and slender, apex sharp, upper margin with a smooth carina, one or two small tubercles near base, cutting edge with several small tubercles. Carpus with four sharp spines on upper margin, upper surface deeply grooved. Merus with several small sharp spines along upper margin. The whole of the great chelae and all the pereopods densely hirsute.

Habitat.—New South Wales: Belmore Falls Creek, Kangaroo River (type locality), in streams above the falls (Melbourne Ward); Sublime Point, Bulli Pass (Consett Davis).

Types in the Australian Museum, Sydney.

Described from a large series comprising two paratypes, received on loan from the Australian Museum, and fresh material from Messrs. Ward and Davis. The large number of specimens examined has shown the species to warrant specific rank.

The specimen from Bulli was collected in a burrow some three feet below the soil surface, near Sublime Point, about 1,300 ft. above sea-level.

Euastacus suttoni sp. nov.

Plate V.

Length of largest specimen 200 mm.

Rostrum very broad, reaching base of third segment of second antennae, apex short and blunt; lateral carinae obtuse, carried well back on to carapace. An obtuse punctate carina ending in a small tubercle at base of each carina, and a large rounded boss posterior-laterally to it.

Second antennae short, reaching second abdominal segment. Squame smooth, inner lobe broad, terminal spine short and sharp. Interantennal spine long and slender, lateral margins serrated.

Carapace densely punctate, almost twice as long as broad, slightly broader than high, as long as abdomen. Branchiostegites densely studded with small tubercles. Cervical groove very deep; branchio-cardiac grooves prominent; areola broad.

Abdomen spinose. First segment with a long slender sharp spine on each lateral lobe, and usually another small spine above each lateral spine. Second segment with three or four long slender sharp spines along each lateral margin; and three or four rows of short, sharp spines above them. Segments three, four, five and six each with one long slender sharp spine near the lateral margin, and several rows of short, sharp spines above the lateral spines, the spines numerous on dorsum of each segment. The number of rows of spines varies considerably on both sides of each segment on each of the specimens examined.

Telson long, partly divided at middle by transverse suture, posterior half membranous, a row of three or four sharp spines along each lateral margin of calcareous portion, and numerous small sharp spines on upper surface. Uropods longer than telson, membranous portion relatively long; inner rami each with five or six sharp spines along the outer lateral margin, median carina feeble; outer rami each with numerous small blunt spines along the transverse suture, median carina obsolete. Lobes at base of uropods without spines.

Sternal keel very slender and sharp; lateral processes almost upright, slender and sharp, increasing in size and sharpness from first to fourth, posterior pair deeply grooved; processes between fourth pereopods long and slender.

Pereopods slender.

Great chelae stout, propodus slightly more than twice as long as broad, four small sharp spines along the upper margin, lower margin with an anterior row of small obtuse spines along a prominent carina, and a posterior row of relatively large sharp spines; cutting edge of propodus with three or four large tubercles and several small tubercles, an obtuse spine on the upper surface of propodus at base of cutting edge; several small tubercles in a group near lower margin. A row of three or four sharp spines on underside of propodus from base of dactylus towards carpus. Dactylus with three or four large tubercles and several small tubercles along cutting edge, three or four small sharp spines along upper margin. Carpus stout with three large sharp spines on upper margin, upper surface deeply grooved; merus with a few small sharp spines along the upper margin.

Habitat.—Queensland: Wyberba (E. Sutton).

The armature of the abdomen and the form of the rostrum separate this species from other members of the genus. The numerous small sharp spines, irregularly placed on the abdomen, are very distinctive.

Euastacus fleckeri (Watson).

Astacopsis fleckeri Watson, Mem. Queensland Mus., x, pt. v, 1935, p. 232, pl. xxxiv; l.c., xi, pt. 1, 1936, p. 52; Flecker, Nth. Queensland Nat., iv, 41, 1936, p. 18.

Euastacus fleckeri (Watson), Clark, Mem. Nat. Mus. Vict., x, 1936, p. 17, pl. 3, fig. 17.

Length of largest specimen examined 210 mm.

Rostrum short and broad, reaching base of third segment of second

antennae, apex blunt; lateral carinae rounded, each with three or four tubercles; a punctate carina, ending in a small tubercle, at base of each carina.

Second antennae reaching base of telson; squame smooth, inner lobe broad, terminal spine sharp. Interantennal spine long and narrow, sharply pointed, margins serrated.

Carapace twice as long as broad, broader than high, somewhat shorter than abdomen. Branchiostegites studded with numerous small tubercles.

First abdominal segment with a long sharp spine on lateral lobes; second segment with four or five sharp spines on each lateral margin; remaining segments each with one spine on each lateral margin. There are no other spines or prominences on abdomen.

Telson longer than broad, almost completely divided at posterior third by a transverse suture, posterior third membranous; a small spine on each lateral margin at suture, without other median or lateral spines. Inner rami of uropods with an obsolete median carina ending in a small blunt spine almost on posterior margin, a small blunt spine at posterior third of outer margin. Outer rami each with numerous small spines along the transverse suture. Lobes at base of uropods without spines.

Sternal keel moderately sharp; first pair of lateral processes small and round, increasing in size and sharpness to posterior pair, these large and deeply grooved.

Great chelae stout, propodus more than twice as long as broad, upper margin with four small blunt spines, cutting edge of propodus with one large and three or four small tubercles, lower margin with one or two rows of small tubercles, several small tubercles on upper surface of propodus. Dactylus with two or three small tubercles on cutting edge, upper margin smooth, several small tubercles on upper margin above the cutting edge. Carpus with four or five sharp spines along upper margin, upper surface flat; merus with four or five small spines on upper margin.

Habitat.—Queensland: Root's Creek (type locality); Mossman River and its tributaries; Daintree River.

Readily separated from *E. nobilis* (Dana) by the absence of spines or tubercles from the dorsum of the abdominal segments, the absence of spines on the telson and uropods, and by the form of the carpus.

In the description of the great chelae, Mem. Nat. Mus. Vict., x, 1936, p. 18, a printer's error occurs. The description of the propodus is cut short at the phrase "cutting edge of propodus with one large and 3 or 4 small tubercles" and is followed by the end of the description of the dactylus beginning with the phrase "on cutting edge, upper margin smooth." The corrected description is given above.

Euastacus nobilis (Dana).

Plate VI.

Astacoides nobilis Dana, U.S. Explor. Exped., Crust., pt. 1, 1852, p. 526, pl. 33.

Astacoides nobilis Dana, Hess, Archiv. f. Naturg., xxxi, 1865, p. 164; Heller, Reise Novara, Zool., ii, pt. 3, Crust., 1865, p. 101; von Martens, Ann. Mag. Nat. Hist., ser. 3, xvii, p. 360, 1866.

Astacus nobilis (Dana), von Martens, Monatsber. Akad. Wiss. Berlin, p. 616, 1868.

Astasopsis nobilis (Dana), Haswell, Cat. Austrl. Mus., Crust., 1882, p. 175; Faxon, Proc. U.S. Nat. Mus., xx, p. 675, 1898; Faxon, Mem. Mus. Comp. Zool., xl, 8, 1914, p. 402.

Astacopsis serratus (Shaw), Smith, Proc. Zool. Soc. Lond., p. 157, 1912; McCulloch, Rec. Austrl. Mus., no. 11, p. 237, 1911.

Euastacus nobilis (Dana), Clark, Mem. Nat. Mus. Vict., x, 1936, p. 15, pl. iii, fig. 15; Clark, Vict. Year-Book, 1936-37, p. 35.

Astacopsis kershawi Smith, Proc. Zool. Soc. Lond., 1912, p. 160, pl. xix.

Euastacus nobilis s. sp. *kershawi* (Smith), Clark, Mem. Nat. Mus. Vict., x, 1936, p. 16, pl. iii, fig. 16; Clark, Vict. Year-Book, 1936-37, p. 35.

Length of average adult specimen 263 mm.

Rostrum broad, reaching base of third segment of second antennae, apex long, slender and sharp; lateral carinae obtuse, continued well back on to carapace, punctate, each with one large tubercle at apex, and two or three smaller tubercles posterior to it. A blunt, punctate carina, and a large rounded boss with a small tubercle, posterior-laterally to it.

Second antennae reaching fourth abdominal segment. Squame smooth, inner lobe broad, terminal spine long, slender and sharp. Interantennal spine broadly triangular.

Carapace more than twice as long as broad, broader than high, as long as abdomen. Branchiostegites sparsely studded with small tubercles, two or three small blunt spines anteriorly on each branchiostegite below cervical groove, with or without larger tubercles along the dorsum of each branchiostegite. Entire carapace sparsely punctate.

Abdomen spinose and tuberculate. First segment with a long sharp spine on each lateral lobe. Second segment with three long slender sharp spines at each lateral margin, a large sharp spine above the lateral spines, and a very large rounded boss above these spines. Third and fourth segments each with a long stout sharp spine at each lateral margin; a very slender long sharp spine and a broad sharp spine above the lateral spines, and a very large rounded boss above these spines, much smaller on fourth segment. Fifth segment with a long stout sharp spine at each lateral margin, two slender sharp spines above the lateral spines. Sixth segment with a small sharp spine near each lateral margin, and a small sharp spine above it.

Telson long and broad, with a long, slender sharp spine on each lateral margin at the transverse suture, several short sharp spines on upper surface. Uropods longer than telson; inner rami each with three or four short sharp spines along the outer lateral margin, median carina very feeble, ending in a small sharp spine near the posterior margin, two small sharp spines along the carina; outer rami each with a spine on outer lateral margin at the transverse suture, numerous very small spines along the suture. Lobes at base of uropods with upper lobe produced to a very short sharp spine.

Sternal keel moderately sharp; lateral processes large and moderately sharp, processes between third pereopods very large and deeply grooved; processes between fourth pereopods long and slender.

Great chelae short and stout, propodus more than twice as long as broad, upper margin with four sharp spines, lower margin with two rows of widely separated short sharp spines, apex sharp, cutting edge with two large and several small tubercles, a broad sharp spine on upper surface near base of cutting edge, another sharp spine at base of dactylus; a few small tubercles

on upper surface below base of dactylus. Dactylus stout, a row of small spines along the upper margin, and a group of small sharp spines near apex, apex sharp, cutting edge with four large and a few small tubercles, two or three small spines in a row above the cutting edge. Carpus with two or three large sharp spines on upper margin, upper surface deeply grooved. Merus with three large and two small spines along the upper margin.

Pereopods armed with numerous long, slender sharp spines.

Habitat.—New South Wales: Blue Mountains, caught in streams leading to Horseshoe Falls and Bridal Veil Falls, above the Falls, (Melbourne Ward); Grose River, Blackheath (E. Clark); Swamp on top of Bulli Pass (Austrl. Museum); Wollongong (W. Kershaw); Parramatta River; Sydney (Australian Museum).

Victoria: Bruthen (J. Barlin); Narracan River (W. Kershaw); Moe River (W. Kershaw); Thomson River (R. James); Lakes Entrance; Thorpdale (W. Kershaw); Vereker Range, Wilson's Promontory (J. A. Kershaw); Ferntree Gully (S. W. Fulton); Belgrave (S. W. Fulton); Warburton, Yarra River (F. J. Williams); Gordon's Bridge, Yea River (E. Clark); Marysville, Stevenson River (E. Clark).

In a previous paper (2) *kershawi* was retained as a subspecies of *nobilis* on characters that were acknowledged to be slight but constant. Examination of the present comprehensive series from Victoria and New South Wales has shown that there is no constancy, examples of both forms as well as intermediate forms being found in the series. Therefore the name *kershawi* is included under *nobilis* as one very variable species found in the coastwise rivers in New South Wales and Eastern Victoria.

Great variation is shown in the armature of the carapace, even among specimens of the same growth stage and taken from the same locality. In some examples there are numerous small tubercles and several large flattened tubercles on each branchiostegite; others have only two or three large tubercles on each branchiostegite; others have large tubercles on only one branchiostegite; some of the examples have no large tubercles on the branchiostegites.

The number of spines on the carpus varies, even on different appendages of the same individual. Two large sharp spines are found on the upper margin of the carpus of the majority of the specimens examined, but many have three large sharp spines as in the type of the species; several examples have two spines on one carpus and three on the other.

Euastacus bispinosus sp. nov.

Plate VII.

Length of average adult specimen 295 mm.

Rostrum broad, reaching almost to end of third segment of second antennae, apex short and blunt; lateral carinae obtuse, carried well back on

to the carapace, punctate, each with two or three small tubercles near apex. An obtuse, punctate carina ending in a very small tubercle at base of each carina, and a large rounded boss posterior-laterally to it.

Second antennae reaching fourth abdominal segment. Squame smooth, inner lobe broad, terminal spine sharp, short and stout. Interantennal spine broadly triangular.

Carapace less than twice as long as broad, broader than high, slightly shorter than abdomen. Entire carapace densely punctate. Branchiostegites sparsely studded with small tubercles, with or without large flattened tubercles along the dorsum of each branchiostegite, one small blunt spine anteriorly on each branchiostegite below the cervical suture.

First abdominal segment with a short sharp spine on each lateral lobe. Second segment with two slender sharp spines at each lateral margin; a broad blunt spine above the lateral spines, and a rounded boss above these spines. Third and fourth sergments each with a long slender sharp spine at each lateral margin; a long broad blunt spine above the lateral spine, and a broad rounded boss above these spines, smaller on fourth segment. Fifth segment with a long slender sharp spine at each lateral margin, two short broad blunt spines above the lateral spines. Sixth segment with a small sharp spine near each lateral margin, and a very small blunt spine above it.

Telson very long and broad, with a very short sharp spine on each lateral margin at the feeble transverse suture, several short blunt spines on upper surface. Uropods as long as telson, inner rami each with three or four very short sharp spines along the outer lateral margin, median carina almost obsolete, ending in a very small blunt spine near the posterior margin, two or three small blunt spines marking the carina; outer rami each with three or four small blunt spines along the outer lateral margin, transverse suture feeble serrated. Lobes at base of uropods rounded.

Sternal keel moderately sharp; lateral processes large and moderately sharp, processes between third pereopods very large and deeply grooved; processes between fourth pereopods long and slender.

Great chelae long and stout, propodus more than twice as long as broad, upper margin with four sharp spines, lower margin with two rows of short spines, apex sharp, cutting edge with two large and several small blunt spines in a row on upper surface near the cutting edge, several small tubercles in a group on upper surface below the base of dactylus. Dactylus long and stout, one or two small spines on upper margin near base, and two or three near the apex, apex sharp, several large tubercles along cutting edge, four or five small spines in a row on upper surface above the cutting edge. Carpus with two long sharp spines on upper margin, upper surface deeply grooved. Merus with one large and three small spines along the upper margin.

Pereopods armed with numerous short sharp spines.

Habitat.—Victoria: Glenelg River (type locality) (H. Pritchard); Crawford River (J. McEachern); Upper reaches of Wannon River (H. Finlayson).

The two rows of spines on each side of the abdominal segments, in addition to the large rounded boss, at once separate this species from others of the genus. Although somewhat resembling *E. nobilis,* it is separated by the arma-

ture of the carapace and abdomen, and by the form of the rostrum, squame and great chelae.

E. bispinosus is the species that is fully figured, with its complete life history, in the paper under the title "The Life History of the Gippsland Crayfish," Australian Museum Mag., April-June, 1937, p. 186.

DISTRIBUTION.

During the progress of the foregoing revision sketch maps (Plates viii and ix) were prepared to illustrate the known distribution of the genus *Euastacus,* but in connection with three species (*elongatus, armatus* and *yarraensis*), the distribution as shown thereon does not conform with the present river system; their distribution is made intelligible, however, if we accept Professor Gregory's theories (37) of the development of the Victorian river system which are supported by the work of Fenner (36), Jutson (39, 40) and others. Gregory's theories are not accepted by certain authors, e.g. Hills (38) and Edwards (35).

Since crayfishes of the genus *Euastacus* inhabit rivers and creeks, seldom leaving the water to wander for considerable distances on land as is done by members of allied genera, their distribution is more or less dependent upon the river system.

As mentioned in a previous page, the Murray River contains two distinct species *E. elongatus,* sp. nov., and *E. armatus* (von Martens). *E. armatus* occurs in two sections of the Murray, one from its source to Cobram and the other from west of Swan Hill to the mouth of the river; and also in the rivers connecting with these sections both in New South Wales and Victoria. *E. elongatus* inhabits the section of the Murray River between the Broken River and Swan Hill and also the rivers flowing into this section of the Murray.

Strange as this demarcation seems at first sight, it is correlated with the findings in other branches of science.

Mr. A. S. Kenyon, former Chairman of the State Rivers and Water Supply Commission, has kindly supplied me with his notes on the River Murray system (see Appendix). He considers that in times of flood the sections of the Murray in which *armatus* occurs, together with the Edward, form the Murray proper and that the section where *elongatus* is found may be considered an extension of the Goulburn. This theory of the distribution of the flood waters supplies one reason for the curious distribution of the two species in the Murray.

E. elongatus, as already mentioned, is found in tributaries

entering the Murray between Cobram and Swan Hill. The principal of these is the Goulburn and its tributaries. *E. elongatus* is found in the Upper Goulburn and its tributaries

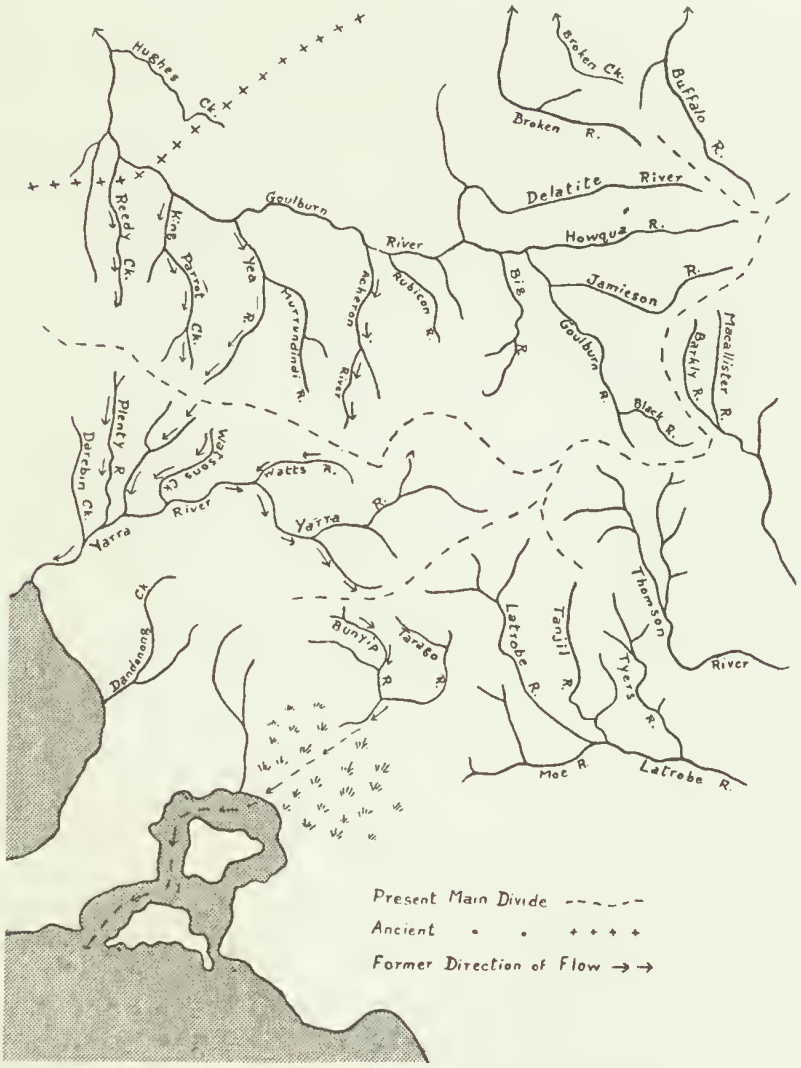


FIG. 1.

Map illustrating Gregory's theory of river development in Victoria.

from the north and east (the Jamieson, the Howqua and the Delatite Rivers), but in tributaries from the south, such as the Acheron and Yea Rivers and King Parrot Creek, *elongatus* gives place to *yarraensis,* which occurs also in all

streams south of this part of the watershed flowing into Port Philip and the Kooweerup Swamp.

This apparently anomalous distribution of *elongatus* and *yarraensis* supports the views of Professor J. W. Gregory and of some other physiographers.

According to Gregory (37) the Cobaw and Strathbogie Ranges formed the original watershed between the Goulburn and the Yarra River systems, and owing to river capture the watershed has moved southward to its present position. King Parrot Creek, the Plenty River and the Lower Yarra probably formed one river, the upper part of which (King Parrot Creek) has been captured by the Goulburn. Also the Yea River and Steel's Creek formed one stream which crossed the basin of the Upper Yarra, where it was joined by a tributary formed by the Acheron and the Watts; the united streams then passed through the Beenak Gap into Kooweerup Swamp and thence to Western Port. The Acheron and the Yea have been captured by the Goulburn.

A glance at the sketch map (fig. 1) shows that this interpretation of the development of the present river system offers a reasonable explanation of the apparently anomalous distribution of *yarraensis*.

Returning to the distribution of *elongatus,* it has been observed that it inhabits the headwaters of the Goulburn River and certain tributaries. Up to the time of writing, no specimen of the genus has been received from the section of the Goulburn River between Alexandra and Seymour, although numerous attempts have been made to obtain specimens. Whether the species will be found to inhabit the entire length of the Goulburn or whether it inhabits only the upper reaches of the river, remains to be seen.

With the distribution of *elongatus* as it stands at present, we find that the species follows out the old river system indicated by Fenner (36). Fenner considered that the Goulburn River originally flowed north to the Murray by way of the Barjarg Gap, and that the Broken River originally flowed south-west through the Black Swamp and on to the Goulburn. It is interesting to see that *elongatus* is found all along the Broken River, in the Goulburn from its junction with the Broken to the Murray, and in the headwaters of the Goulburn and the surrounding rivers.

The distribution of a fourth species, *E. nobilis* (Dana), is also curious as far as the present river system is concerned.

South of the Main Divide this species occurs in all rivers from the Latrobe River east to New South Wales and in the

coastwise rivers of that State as far north as Sydney. In Victoria it also inhabits the headwaters of the Yarra River and its tributaries above Warburton, but so far only small specimens averaging six inches in length from rostrum to telson have been received from this area.

North of the Main Divide it inhabits the Stevenson River and the headwaters of the Yea. On the map (Plate IX) the Stevenson River is indicated but is not named. In rises on Mt. Grant and flows past Marysville to join the Taggerty, the combined rivers then joining the Acheron at Buxton. Small specimens have been taken at Gordon's Bridge on the Yea River, but comparatively large specimens have been taken from the Stevenson—one male measured 9½ inches from rostrum to telson.

In setting out the above facts regarding the distribution of the four species, no attempt is made to assert that they are proof of any of the theories mentioned, but the evidence obtained regarding the rivers which at some previous time must have been connected since the genus *Euastacus* is dependent upon the river system for its dispersal, has been put forward so that it may be of some assistance to future workers both on the distribution of the Australian crayfishes and on the development of Victorian physiography. As has been mentioned previously consideration of the theories is the only way in which the otherwise anomalous distribution of the genus can be explained.

APPENDIX.

The following paragraphs, which have a bearing on the distribution of *E. elongatus* and *E. armatus,* are taken from Mr. A. S. Kenyon's unpublished notes on the Murray River system:—

The Murray River, though generally looked upon as one and the same river throughout its course, is truly so only in times of low and moderate flow. Taking its rise in the Australian Alps, it flows in a normal manner along its valley to the foothills, rolling along its bed vast masses of boulders, shingle and gravel. Emerging upon the old lacustrine plains at Corowa and Yarrawonga, it leaves the stones and gravel behind, carrying onward only the sand resulting from their grinding higher up, with the silts and clays in suspension derived from the erosion of its banks and from the land slides, in wet seasons, on the steep sides of the mountain valleys.

Shortly after it enters the plains and receives the waters of the Ovens River, the Murray begins, definitely at Cobram and Tocumwal to assume a deltaic character; and in flood times completely loses its identity in what can best be named and described as the Moira Marshes.

Into the Moira Marshes also pour the floods of the Goulburn River. From

the Marshes emerge two Rivers—one passing Deniliquin is named the Edward, while the other passing Echuca, retains the title of the Murray; but in times of high flood at least, it would be more correct as far as the source of the water might govern the question, to call the Edward the Murray—and the Murray the Goulburn.

Following on with the Murray, it, after receiving the Campaspe contribution at Echuca, has a very short existence as a normal stream, entering another series of marshes, which may be termed the Gunbower Marshes, just below Perricoota. From this network of swamps and flooded areas, emerge the Gunbower Creek with its attendant system, leaving in the main channel running between Murray Downs and Swan Hill, only an insignificant remnant of the original flood volumes poured in by the Upper Murray, the Ovens, the Goulburn, the Campaspe and other tributaries.

Below Swan Hill, the overflows gradually return until at the Wakool Junction the Murray, now restored to its single character, enters the Mallee canyon and continues within its confines until it approaches the Murray Mouth Lakes.

The Edward River below Deniliquin behaves somewhat similarly to the Murray River, becoming deltaic in character and spreading across country by the Niemur and Wakool River to join the Thule and Merran waters. It also picks up the waters of the Billabong Creek, a real river, but mixed with overflows from the Murrumbidgee River. It might be said that the Murray River ceases at Tocumwal, the Billabong Creek at Jerilderie and the Murrumbidgee River at Narrandera. Everything below being a deltaic jumble.

BIBLIOGRAPHY of *Euastacus*.

1. Blandowski, W. Recent Discoveries in the Natural History on the Lower Murray. Trans. Phil. Inst. Vict., vol. ii, pt. ii, 1858, p. 130.
2. Clark, E. The Freshwater and Land Crayfishes of Australia. Mem. Nat. Mus., Vict., x, 1936, pp. 5-58, pls. i-xi.
3. Clark, E. The Life-History of the Gippsland Crayfish. Australian Mus. Mag., vi, 6, 1937, pp. 186-192.
4. Dana, J. Family Astacidae. Report U.S. Eplor. Exped., xii, Crust., pt. 1, 1852, pp. 520-528.
5. Erichson, W. F. Uebersicht der Arten der Gattung Astacus. Arch. f. Naturg., xii, 1846, pp. 86-103.
6. Erichson, W. F. Nachtrag zur Uebersicht der Arten der Gattung Astacus. Arch. f. Naturg., xii, 1846, pp. 375-377.
7. Faxon, W. Observations on the Astacidae in the United States National Museum, and in the Museum of Comparative Zoology, with descriptions of New Species. Proc. U.S. Nat. Mus., xx, 1898, pp. 643-694.
8. Faxon, W. Notes on the Crayfishes in the United States National Museum and the Museum of Comparative Zoology, with descriptions of new species and subspecies, to which is appended a catalogue of the known species and subspecies. Mem. Mus. Comp. Zool., xl, no. 8, 1914, pp. 351-352, 401-402.
9. Flecker, H., and P. O. The Haunt of the North Queensland Spiny Crayfish. Nth. Qld. Nat. iv, 41, 1936, pp. 18-20.
10. Gray, J. E. New Species of the Genus *Astacus*. Eyre's Journ. Exped. Disc., Central Australia i, (Appendix), pp. 407-411, pl. 3.

11. Hale, H. M. Handbook Crustacea of South Australia, 1927, pp. 72-77, figs. 69-73.
12. Haswell, W. A. Catalogue of Australian Museum, Crustacea, 1882, pp. 174-179.
13. Heller, C. Reise der Fregatte Novara, Zool., ii, pt. 3, Crust., 1865, pp. 100-104.
14. Huxley, T. H. On the Classification and Distribution of the Crayfishes. Proc. Zool. Soc. Lond., 1878, pp. 752-788.
15. Huxley, T. H. The Crayfish. International Scientific Series, xxviii, 1880, p. 306.
16. McCoy, F. Recent Zoology and Paleontology of Victoria. Ann. Mag. Nat. Hist., ser. 3, xx, 1867, p. 189.
17. McCoy, F. Prodromus of the Zoology of Victoria, i, dec. 2, 1878, p. 17, pl. 15.
18. McCoy, F. Prodromus of the Zoology of Victoria, ii, dec. 16, 1888, p. 225, pl. 14.
19. McCulloch, A. R. Notes on Variation in *Astacopsis serratus* Shaw. Records Austrl. Mus. no. 11, 1917, pp. 237-238, pl. xliii.
20. Milne-Edwards, M. *Astacus australasiensis*. Hist. Nat. Crust., ii, 1837, p. 332, pl. 24, figs. 2-5.
21. Milne-Edwards, M., and Audouin. Arch. du Mus. d'Hist. Nat., ii, 1841, p. 36.
22. Nobili, G. Contribuzione alla conoscenza della fauna carconologica della Papuasia, delle Molucche e dell'Australia. Ann. Mus. Civ. St. Nat. Genova, xl, 1899, p. 244.
23. Nobili, G. On Two Parastacidi from New Guinea. Bol. Mus. Zool. Torina, xviii, no. 445, 1903, p. 1.
24. Ortmann, A. E. Die Decapoden Krebse des Strassburger Museum, III. Zoolog. Jahrb., Syst. vi, p. 7, pl. 1, fig. 2, 1891.
25. Ortmann, A. E. Semon's Zoolog. Forsch, in Austral., v, p. 21.
26. Roux, J. A propos des genres Astaconephrops *Nobili* et *Cheraps* Erichson. Zool. Anz. Leipzig, 37, 1911, pp. 104-106.
27. Roux, J. Nouvelles especies de decapodes d'eau douce provenant de Papouasie. Leyden Museum Notes, xxxiii, 1911, pp. 81-105, figs. 2-5.
28. Shaw, G. Zoology of New Holland, i, p. 21, pl. 8, 1794.
29. Smith, G. The Freshwater Crayfishes of Australia. Proc. Zool. Soc. Lond., 1912, pp. 144-170, pls. xiv-xxvii.
30. Spence-Bate, C. Report Voyage H.M.S. Challenger, Crust. Macr., xxiv, 1888, pp. 192-206, pls. xxvii-xxviii.
31. von Martens, E. On a New Species of *Astacus*. Ann. Mag. Nat. Hist., 3, xvii, 1866, p. 359.
32. von Martens, E. Uberblick der neuhollandischen Flusskrebse. Monatsber. Akad. Wiss. Berlin, 1868, pp. 615-619.
33. Watson, K. A new *Astacopsis* from North Queensland. Mem. Qld. Mus., x, pt. v, 1935, p. 232, pl. xxxiv.
34. Watson, K. *Astacopsis fleckeri*. Mem. Qld. Mus., xi, pt. 1, 1936, p. 52.

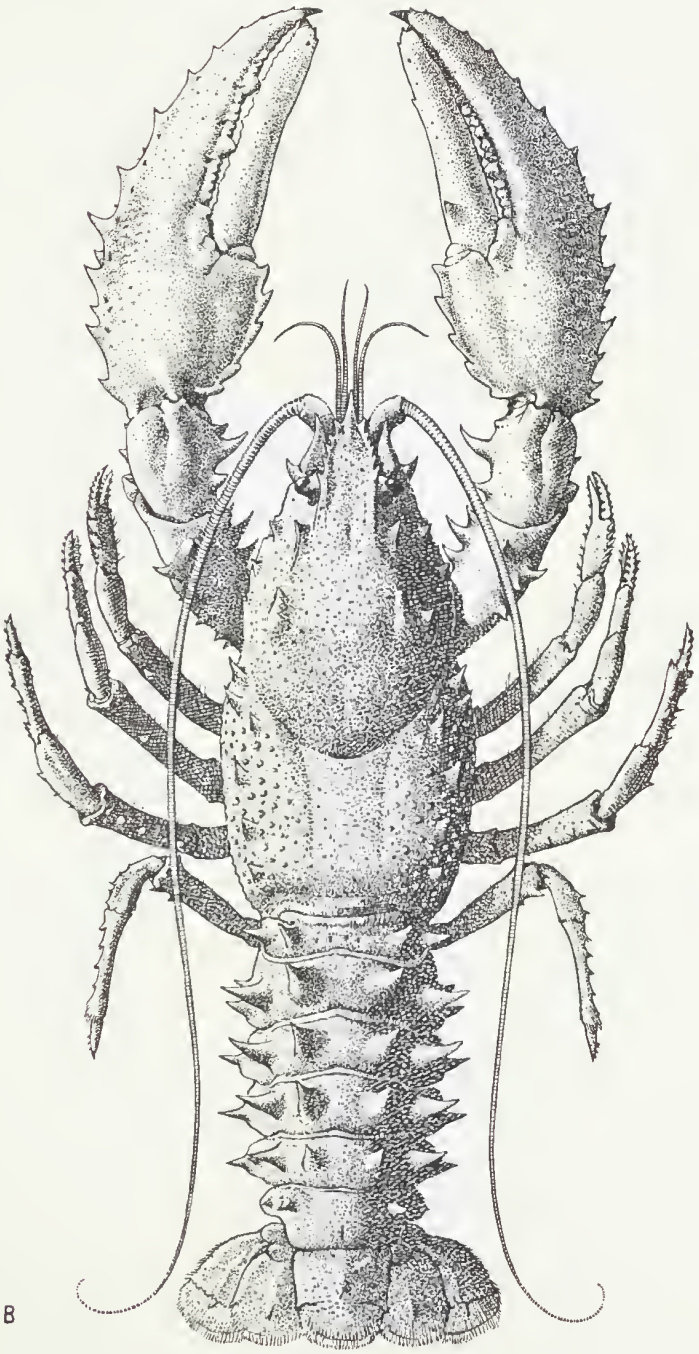
GEOGRAPHICAL REFERENCES.

35. Edwards, A. B. A note on the Physiography of the Woori Yallock Basin. Proc. Roy. Soc. Vict., 52 (N.S.) pt. ii, 1940, pp. 336-341.
36. Fenner, C. Physiography of the Mansfield District. Proc. Roy. Soc. Vict., 26 (N.S.), pt. ii, 1914, pp. 386-402.

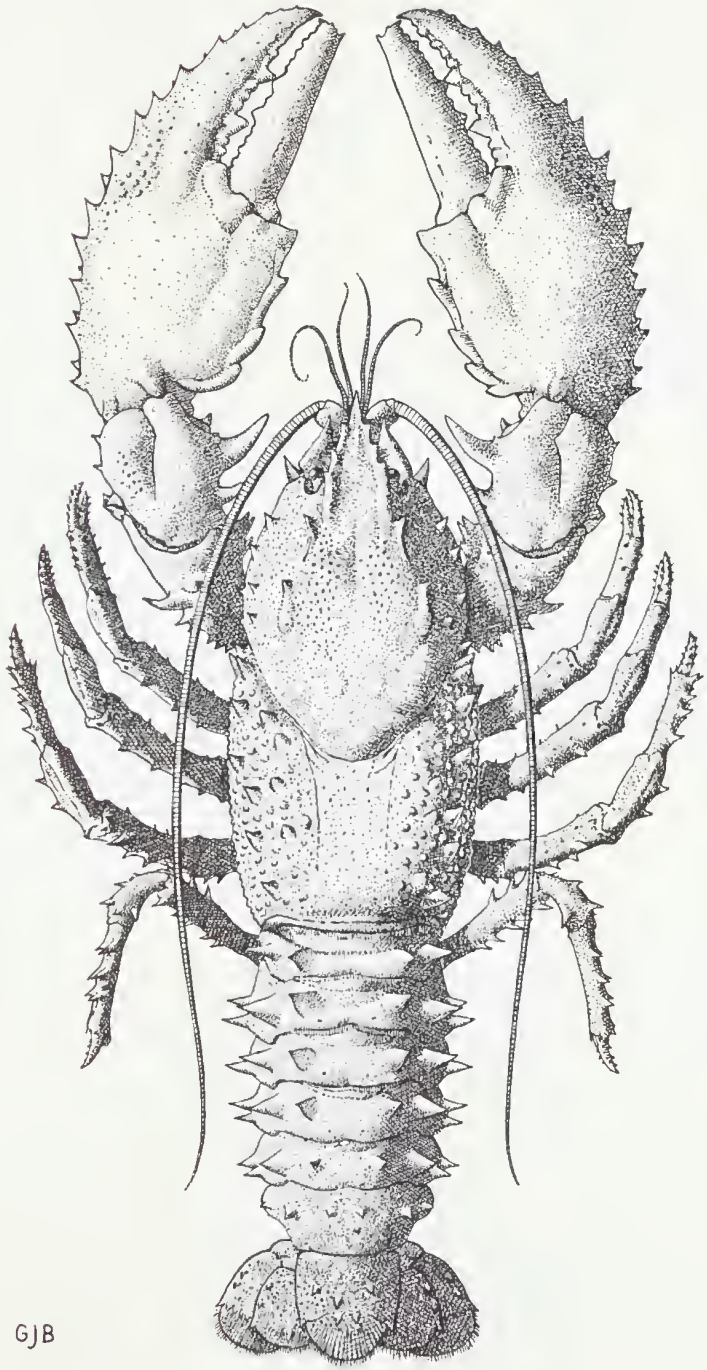
37. Gregory, J. W. The Geography of Victoria. Melbourne, 1903, pp. 105-123; revised edition, 1912, pp. 106-127.
38. Hills, E. S. Some Fundamental Concepts in Victorian Physiography. Proc. Roy. Soc. Vict., 47 (N.S.), pt. i, 1934, pp. 148-174.
39. Jutson, J. T. A contribution to the Physical History of the Plenty River; and of Anderson's Creek, Warrandyte, Victoria. Proc. Roy. Soc. Vict., 22 (N.S.), pt. ii, 1909, pp. 153-171.
40. Jutson, J. T. A contribution to the Physiography of the Yarra River and Dandenong Creek Basins, Victoria. Proc. Roy. Soc. Vict., 23 (N.S.), pt. ii, 1911, pp. 467-514.

PLATES.

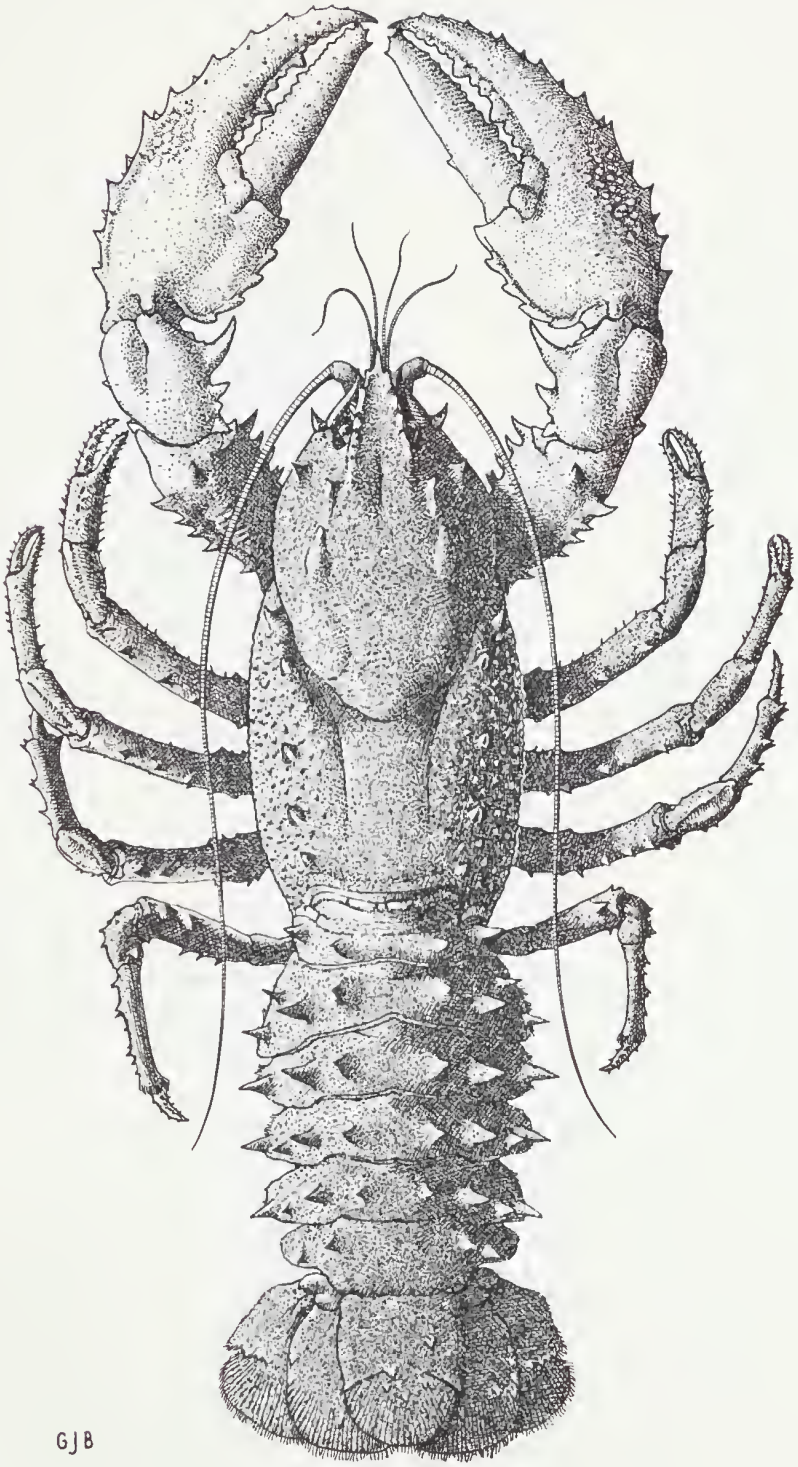
I. *Euastacus elongatus* sp. nov.
II. *E. armatus* (von Martens).
III. *E. yarraensis* (McCoy).
IV. *E. serratus* (Shaw).
V. *E. suttoni* sp. nov.
VI. *E. nobilis* (Dana).
VII. *E. bispinosus* sp. nov.
VIII. and IX. Locality Maps.



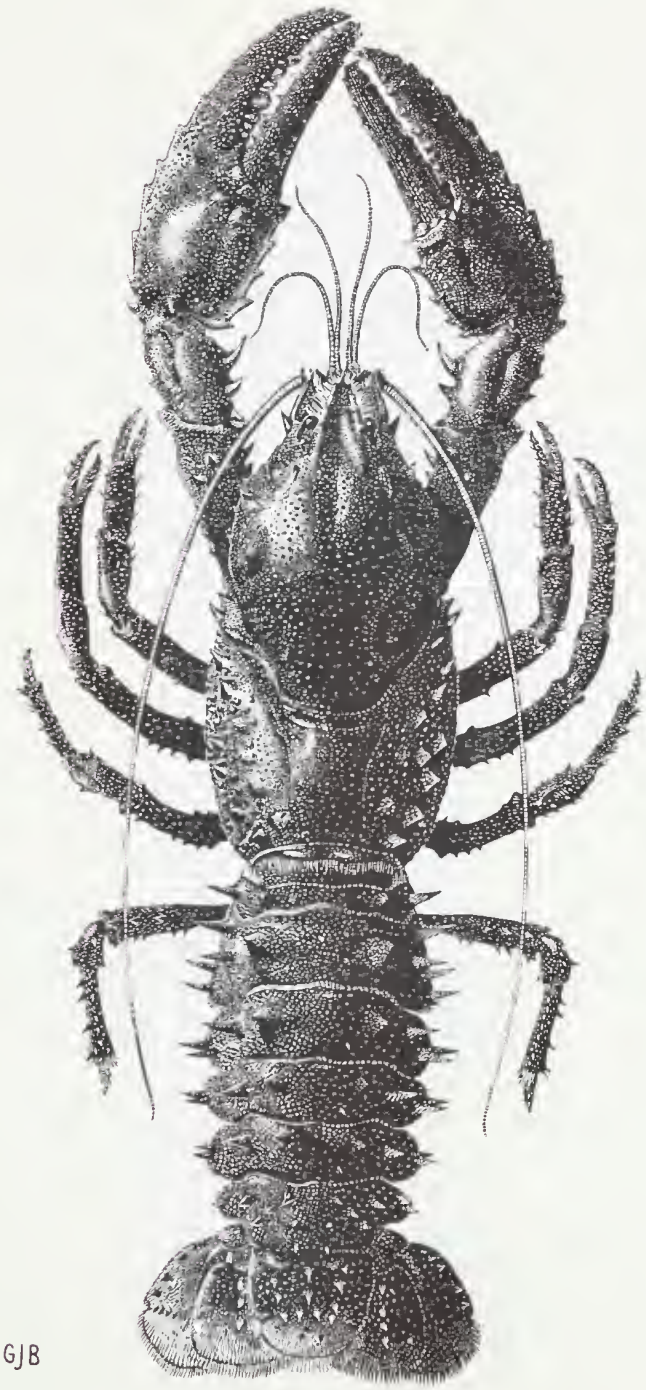
Euastacus elongatus Clark



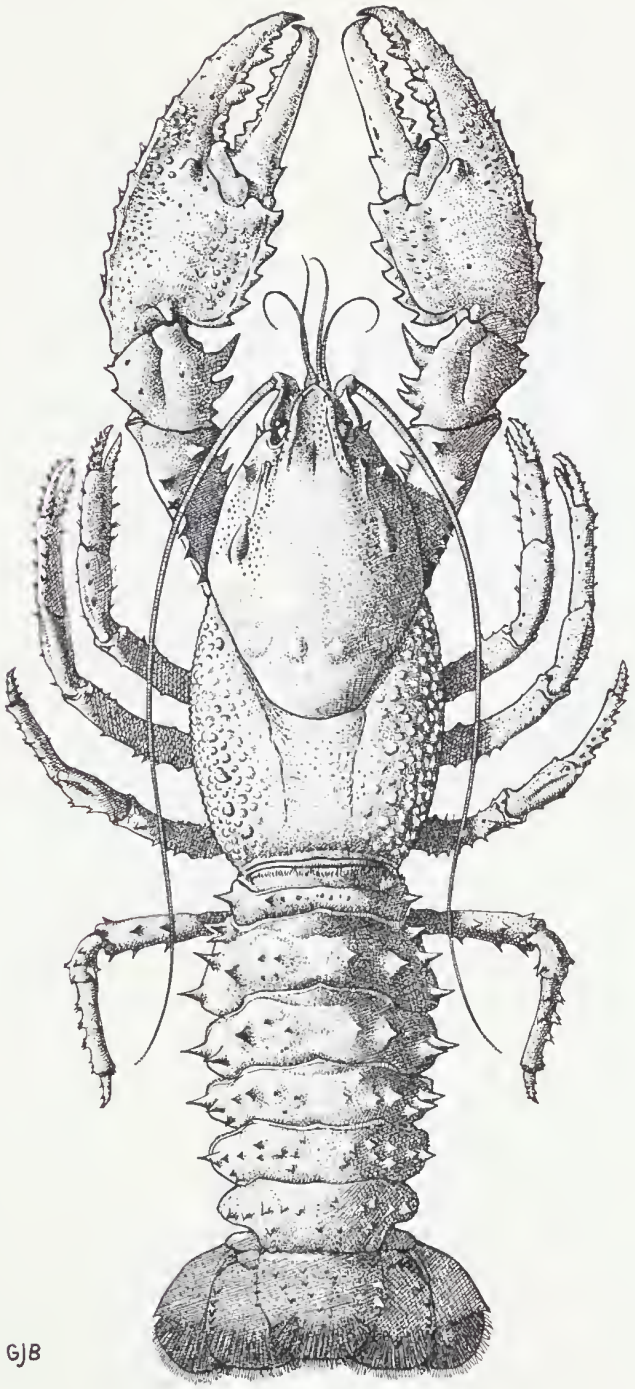
Euastacus armatus (von Martens)



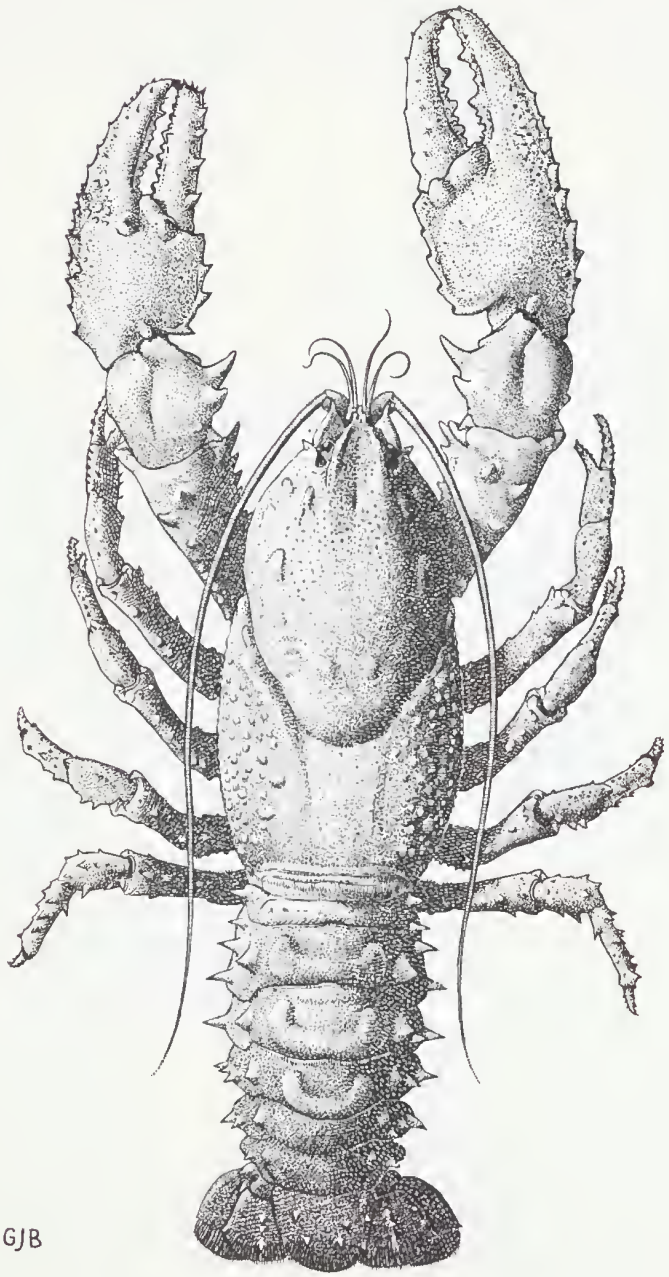
Euastacus yarraensis (McCoy)



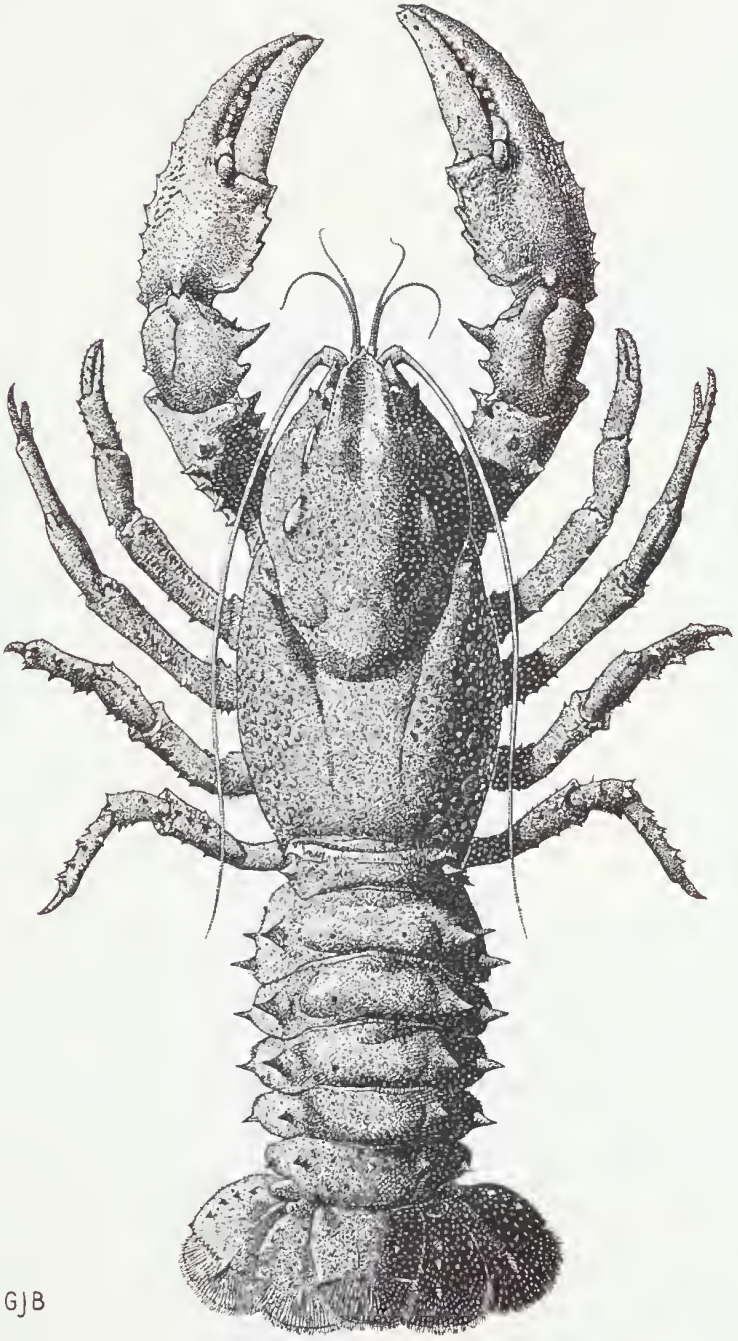
Euastacus serratus (Shaw)



Euastacus suttoni Clark



Euastacus nobilis (Dana)



Euastacus bispinosus Clark

Locality Map: part of Victoria and Riverina District, N.S.W.

Del. E. Clark.

Locality Map: part of Central and Southern Victoria

NEW SPECIES OF AUSTRALIAN FRESHWATER AND LAND CRAYFISHES (Family PARASTACIDAE)[1]

By Ellen Clark.

Plate X.

In the following pages seven new specimens belonging to four genera are added to the Australian section of the family Parastacidae, and one previously described species is reinstated.

Genus CHERAX Erichson.

Astacus (*Cherax*) Erichson, Arch. f. Naturg., xii, 1846, pp. 88-89.
Astacus (*Cheraps*) Erichson, l.c., p. 101.
Cherax Er., Clark, Mem. Nat. Mus. Vict., v, 1936, p. 18.

In the paragraph referring to the derivations of the name *Cherax* (Mem. Nat. Mus. Vict., 10, p. 19), a printer's error occurs in the Greek lettering; for Χάταξ read χαραξ and for χαζάσσειν read χρασσειν.

This is the most widely distributed Australian genus. Seven species have already been described, and with the addition of three species described herein, ten species are now included in the genus. Three of the species (*C. quinquecarinatus* (Gray), *C. bicarinatus* (Gray), and *C. tenuimanus* (Smith) are found in the south-west of Western Australia; three species (*C. punctatus* Clark, *C. rotundus* sp. nov., and *C. davisi* sp. nov.) occur in coastal areas in New South Wales and Queensland; *C. albidus* Clark is found in Victoria, New South Wales and South Australia; *C. destructor* Clark in Victoria, New South Wales, South Australia, Central Australia, Queensland and Dunk Island; *C. quadricarinatus* (von Martens) has been found in the Northern Territory, Queensland, New Guinea and the Aru Islands; and *C. barretti* sp. nov., is described from the Wessell Islands, off the north coast of Australia.

The genus has not been recorded from Tasmania nor Kangaroo Island, although the closely allied genus *Geocharax* is found in each of these islands.

Cherax barretti sp. nov.

Plate X, Fig. 1.

Length of type male, 57 mm.

Rostrum broad, reaching almost to base of third segment of second antennae, apex obtuse, carinae sharp, three or four small tubercles on each carina near apex; lateral carinae sharp, ending in a small rounded boss, a small sharp spine anteriorly on each carina.

[1]Results of work assisted by a grant from the Commonwealth Research and Endowment Fund.

Squame of each second antenna slender, terminal spine short and sharp. Interantennal spine short and broad, apex sharp, lateral margins rather sharp.

Carapace shorter than abdomen, broader than high, densely punctate; branchio-cardiac grooves obsolete, areola very broad; four or five small sharp spines along anterior of branchiostegites below the cervical groove.

Telson with a small sharp spine on each lateral margin at posterior third; posterior third of telson membranous. Uropods longer than telson; inner rami each divided by a longitudinal median carina, ending in a small sharp spine at membranous junction, a spine on each outer lateral margin at middle, posterior half of each ramus membranous. Outer rami each divided at apical third by a transverse suture, numerous small sharp spines along the suture, posterior two-thirds of each ramus membranous. Lobes at base of uropods with upper and lower lobes produced to a small sharp spine.

Sternal keel high, very slender and sharp. First two pairs of lateral processes small and sharp, third pair larger, sharp; fourth pair large, concave, each with a small round opening on outer lateral surface, lateral margins sharp; processes between fourth pereopods short, upper surface concave, lateral margins sharp.

Great chelae stout, with a few scattered small punctures; propodus twice as long as broad, upper margin serrated, lower margin smooth, four or five small tubercles along cutting edge; dactylus stout, upper margin smooth, one or two small tubercles along the cutting edge. Carpus with three sharp spines along upper margin and a row of small tubercles on upper surface below the spines, a small spine at anterior margin, surface of carpus punctate. Merus with one large sharp spine and several small tubercles along the upper margin.

Habitat.—Wessell Island, Japanese Creek (C. Barrett).

This species is based on a single specimen obtained by Mr. Charles Barrett from the Wessell Island, which is situated N.W. of the Gulf of Carpentaria, 30 miles from the coast of the Northern Territory. The distinctive characters, however, remove any doubt as to the specimen being an aberrant form of any known species.

In the number of carinae on the carapace *barretti* resembles *C. bicarinatus* (Gray) (6), which was described from specimens collected at Port Essington; Gray's species has not since been recorded from the north, but it is common in the south-west of Western Australia. The types of *bicarinatus* were examined for a previous paper (2) and found identical with *C. intermedius* Smith (12), the types of which are in the National Museum, Melbourne. *C. barretti* and *bicarinatus* may be separated by the form of the rostrum, sternal keel and great chelae.

The only other species known from the north coast of Australia is *C. quadricarinatus* (von Martens) (14). The number of carinae on the carapace immediately separates *quadricarinatus* and *barretti*; other important differences are found in the form of the great chelae and the sternal keel.

The type of *barretti* exhibits a very interesting character recorded by Roux, Nobili and Calman as occurring in males of *C. quadricarinatus*. The propodus of the great chelae bears a soft white patch, equal on both chelae, along the lower margin near the apex. In the figure (Pl. X, fig. 1), this soft portion is indicated by the dotted area.

Cherax davisi sp. nov.

Plate X, Fig. 3.

Length of average adult 107 mm.

Rostrum broad, reaching almost to base of third segment of first antennae, apex obtuse, carinae blunt; lateral carinae blunt, punctate, each ending in a rounded boss.

Squame of each second antenna very broad anteriorly, terminal spine short and sharp. Interantennal spine short and broad, apex blunt, lateral margin serrated.

Carapace shorter than abdomen, broader than high, densely punctate; areola narrow; anterior of carapace and branchiostegites densely minutely punctate.

Telson with a small sharp spine on each lateral margin at posterior third, posterior third of telson membranous. Uropods longer than telson; inner rami each divided by a longitudinal median carina, ending in a small sharp spine at middle, a spine on each outer lateral margin at middle, posterior half of each ramus membranous. Outer rami each divided at apical third by a transverse suture, numerous small sharp spines along suture; posterior two-thirds of each ramus membranous. Lobes at base of uropods with upper lobe produced to a small sharp spine.

Sternal keel slender and sharp, produced to a sharp, backwardly-directed spine below great chelae; first two pairs of lateral processes obsolete, third pair small and sharp, each with a small round opening on outer lateral surface; fourth pair larger, each with a large round opening on upper surface; processes between fourth pereopods short and stout.

Great chelae very stout; propodus two and one-fourth times as long as broad, with a few scattered punctures; upper margin serrated, lower margin smooth, posterior margin with a row of small tubercles; a few small tubercles along the cutting edge of propodus. Dactylus stout, punctate, upper margin smooth, cutting edge with two or three small tubercles. Carpus with a stout, blunt spine, forwardly-directed, on upper margin, two or three small spines near posterior margin; upper margin of merus feebly serrated.

Habitat.—New South Wales: Dumaresq Creek, Armidale (Consett Davis).

At first sight this species appears very close to *Astacoides plebejus* Hess (7), which I have not had the opportunity of examining. The description and figure of *plebejus*, however, do not agree with *davisi* in several important characters. Although there are many points of similarity, the points of difference are such that the species must be separated. For example, the telson of *plebejus* is stated to be longer than the uropods, whereas the telson of *davisi* is shorter than the uropods; in addition, Hess gives no indication as to whether the

telson and uropods are membranous. The rostrum and lateral carinae differ in the two species.

Separated from *C. albidus* Clark, by the broader, more rounded rostrum; the more slender sternal keel; the narrow areola; and the shape of the sternal keel.

Described from a large series of specimens received from Mr. Consett Davis.

Cherax rotundus sp. nov.

Plate X, Fig. 2.

Length of average adult specimen 107 mm.

Rostrum short and broad, reaching base of second segment of first antennae, apex rounded; carinae blunt; lateral carinae feeble, each ending in a rounded boss.

Squame of each second antenna very broad anteriorly, terminal spine short and sharp. Interantennal spine short and broad; apex obtuse.

Carapace densely punctate; branchiostegites densely, minutely tuberculate; cervical groove deeply impressed; branchio-cardiac grooves deeply impressed; areola narrow. Anterior of carapace as broad as posterior, giving an appearance of great rotundity.

Abdomen densely punctate. Telson longer than broad, with a spine at apical third of each lateral margin; posterior third of telson membranous. Uropods longer than telson; inner rami each divided by a longitudinal median carina ending in a small sharp spine at membranous junction; a spine on each lateral margin at middle; posterior half of uropods membranous; outer rami each divided at apical third by a transverse suture, numerous small spines along suture; each ramus divided by a longitudinal median carina ending in a small sharp spine at the transverse suture; posterior two-thirds of uropods membranous. Lobes at base of uropods without spines.

Sternal keel slender and sharp; first two pairs of lateral processes very small, third pair larger, posterior pair larger, flattened; processes between fourth pereopods short and stout.

Great chelae short and stout; propodus one and three-fourths times as long as broad, upper surface punctate, upper margin serrated, lower margin smooth, several small tubercles along cutting edge, apex sharp; a large patch of short setae on lower surface of propodus. Dactylus stout, punctate, upper margin smooth, several small tubercles along the cutting edge, apex sharp. Carpus with a stout, blunt spine on upper margin, upper surface with a few punctures; upper margin of merus smooth.

Habitat.—Queensland: Muddy River, Severn (E. Sutton).

This species comes nearest to *C. punctatus* Clark, but may be distinguished by the form of the carapace, great chelae, and the sternal keel.

Genus GEOCHARAX Clark.

Geocharax Clark, Mem. Nat. Mus. Vict., x, 1936, p. 31; Clark, Proc. Roy. Soc. Tasmania, 1938, p. 118.

The genus *Geocharax* is found in various localities in Victoria, on the north coast of Tasmania, and on Kangaroo

Island. Each of the five known species is found in Victoria, the most widely distributed species being *G. gracilis* Clark. It is found in Victoria, Tasmania and Kangaroo Island.

All the species live in the marshy ground along the banks of rivers or creeks.

Key to species of GEOCHARAX Clark.

Rostrum slender.

- Great chelae slender; propodus with upper and lower margins smooth .. .. *laevis* sp. nov.
- Great chelae slender; propodus with upper margin serrated, lower margin smooth .. .. .. *gracilis* Clark.

Rostrum broad.

- Great chelae slender .. .. *lyelli* Clark.
- Great chelae very stout; dactylus sickle shaped .. *falcata* sp. nov.

Geocharax laevis sp. nov.

Plate X, Fig. 4.

Length 52 mm.

Rostrum slender, reaching almost to apex of third segment of first antenna, apex obtuse; carinae sharp, carried well back on to carapace; lateral carinae sharp, not ending in a rounded boss.

Squame of each second antenna long and very slender; terminal spine long, slender and sharp. Interantennal spine small and slender, semi-pyramidal. Median arch of upper lip smooth. Eyes small.

Carapace higher than broad, twice as long as broad, shorter than abdomen. Cervical suture deeply impressed rounded; branchio-cardiac grooves feebly impressed, areola broad. Branchiostegites and anterior of carapace studded with numerous minute tubercles.

Sternal keel broad and blunt between second and third pereopods, high, slender and sharp between first and second pereopods. Lateral margins of lateral processes between second pereopods sharp; processes between third pereopods obliquely flattened, upper margin sharp; sternal keel continued across as an obsolete carina. Processes between fourth pereopods short and slender, upper margins sharp.

Telson entirely calcareous, with a spine on each lateral margin at apical third; inner rami of uropods each divided by a longitudinal median carina, ending in a sharp spine near posterior margin; outer rami each divided by two longitudinal median carinae, inner carina continued across the transverse suture, ending spineless at posterior margin, the transverse suture placed at the apical third, several sharp spines along the suture; a sharp spine at centre of outer lateral margin of each ramus.

Pereopods slender.

Great chelae long and slender. Propodus three times as long as broad; upper margin smooth, lower margin smooth, apex sharp, cutting edge smooth or with two or three small tubercles. Dactylus slender, upper margin smooth, cutting edge smooth or with a few small tubercles, apex blunt. Upper margin of carpus smooth; upper margin of merus with one short sharp spine.

Habitat.—Victoria: Bunyip (D. J. Mahony).

Type in the National Museum, Melbourne.

Although somewhat resembling *G. gracilis* Clark, this species is distinguished by the form of the great chelae, the squame of the second antennae, and the sternal keel.

Geocharax gracilis Clark.

Geocharax gracilis Clark, Mem. Nat. Mus. Vict., x, 1936, p. 31, pl. i, fig. 8, pl. vi, fig. 26; Proc. Roy. Soc. Tasmania, 1938, p. 118, pl. xii, figs. 1, 1a, 1b.

Originally described from Victoria, this species has since been recorded from Smithton, on the north-west coast of Tasmania.

Geocharax lyelli Clark.

Geocharax lyelli Clark, Mem. Nat. Mus. Vict., x, 1936, p. 32, text-fig. 1.

Since the original description of this species, it has been found in the following localities in Victoria:—Lima South, between Benalla and Mansfield (E. Clark); Swanpool (Mrs. G. Clark); Wandon, near Kilmore (A. Massola).

Abundant in the flats along the Broken River, between Benalla and Mansfield, this species was found to be doing great damage to the maize crops growing in that area.

It is interesting to note that the localities mentioned above are on the north of the Main Divide of the Victorian watershed; the other species of the genus have been found only to the south of the Main Divide.

Geocharax falcata sp. nov.

Plate X, Fig. 5.

Length of average adult specimen 80 mm.

Rostrum broad, reaching base of third segment of second antennae; apex blunt, carinae sharp, arched broadly outward posteriorly, carried well back on to carapace; lateral carinae sharp, each ending in a rounded boss.

Second antennae long and slender, reaching the base of third abdominal segment; squame large, reaching the end of third segment of first antenna; terminal spine short and sharp. Interantennal spine long and broad, sharply pointed. Median arch of upper lip smooth and swollen. Eyes moderately large.

Carapace higher than broad, one and one-half times longer than broad, shorter than abdomen. Cervical suture deeply impressed, rounded; branchiocardiac grooves feebly impressed; areola broad. Branchiostegites and anterior of carapace studded with numerous minute tubercles.

Sternal keel narrow, very sharp; first three pairs of lateral processes obsolete, fourth pair flattened downwards; sharp ridge of sternal keel continued across fourth pair of processes. Processes between fourth pereopods long and stout, each with a sharp ridge on upper margin.

Telson with a spine on each lateral margin at apical third; inner rami of uropods each divided by a longitudinal median carina, continued without spines to the posterior margin; outer rami each divided by two longitudinal median carinae, inner carina continued across transverse suture, ending spine-

less at posterior margin, the transverse suture placed at apical third, several small sharp spines along the suture.

Pereopods stout.

Great chelae large and stout. Propodus twice as long as broad, with a few scattered punctures on upper surface, upper margin serrated, lower margin smooth, apex sharp, cutting edge with a few small tubercles, margin formed into a peculiar curve into which the cutting edge of the dactylus conforms. Dactylus slender, sickle-shaped, with a few scattered punctures on surface, upper margin smooth, cutting edge with one small tubercle near base, apex sharp, incurved; propodus and dactylus gaping when closed. Upper margin of both carpus and merus serrated.

Colour.—General appearance from above, light chocolate brown, translucent blue below. Anterior-lateral portion of carapace dark blue; branchiostegites buffy-brown above, fading to grey below. Telson and lateral margins of abdomen buffy brown; uropods light buffy brown tinged with blue. Propodus and carpus dark amber above, lighter on lower margins, bluish sheen below at apex, shading to cream at base; merus light amber at apex, fading to honey at base, with a large bluish area below; dactylus brownish blue above with a bluish sheen below. Pereopods translucent cream, tinged with blue.

Habitat.—Victoria: Grampian Mountains (E. Clark).

The peculiar shape of the great chelae distinguishes this species from all other known members of the family.

Very abundant in the swamp at the head of the Wannon River and Fyans Creek. The burrows descend vertically three or four feet, and almost invariably contain only one occupant.

Genus ENGAEUS Erichson

Astacus (Engaeus) Erichson, Arch. f. Naturg., xii, 1846, p. 102.

Engaeus, Huxley, Proc. Zool. Soc. Lond., p. 769, 1878; Smith and Schuster, Proc. Zool. Soc. Lond., 1913, p. 118; Clark, Mem. Nat. Mus. Vict., x, 1936, p. 37; Clark, Proc. Roy. Soc. Tasmania, 1938, p. 122.

The genus *Engaeus* is found in Victoria and Tasmania. Of the fourteen known species, ten have been found in Victoria, the most widely distributed species being *E. quadrimanus* Clark; it has been found all through the southern half of Victoria, as far north as Benalla, and also on King Island.

Since the publication of the previous revision (2), *E. victoriensis,* Sm. & Sch., has been collected at Mooroopna and Shepparton, on the hills around the Goulburn and Broken Rivers. It is noteworthy that both *E. victoriensis* and *E. quadrimanus* are found along the banks of the Broken River, *E. quadrimanus* being found abundantly between Benalla and Mansfield. These two species are found together at Warburton, Croydon, Ferntree Gully, and in south Gippsland, *E. quadrimanus* inhabiting the swamps and watercourses, whilst *E. victoriensis* burrows in the drier land, usually on the slopes of hills.

Engaeus fultoni Smith and Schuster.
Plate X, Fig. 6.

E. fultoni Sm. & Sch., Proc. Zool. Soc. Lond., 1913, p. 126.
E. fossor, Clark, Vict. Nat., liii, 1936, p. 66, fig. 2; Mem. Nat. Mus., Vict. x, 1936, p. 42.

Length of average adult specimen 53 mm.

Rostrum slender, reaching base of third segment of first antennae; apex sharp and upturned; carinae sharp, carried well back on to the carapace.

Squame of second antennae long and slender, sharply pointed. Inter-antennal spine short, broadly triangular, bluntly pointed. Exopod of third maxillipedes either long and slender, or indicated by a small papilla.

Sternal keel slender and sharp; first three pairs of lateral processes small, each with a conspicuous round opening; processes between third pereopods small and somewhat flattened, slightly grooved, lateral margins blunt, each with a small round opening under the lateral margin; processes between fourth pereopods long and stout.

Telson narrowly cone-shaped, almost as long as uropods, with a spine on each lateral margin; inner rami of uropods rounded, each with a sharp spine on outer lateral margins near posterior margin, divided by a longitudinal median carina ending in a sharp spine near posterior margin; outer rami rounded, with a spine on outer lateral margin above the transverse suture, each divided by a longitudinal median carina, ending in a spine at the transverse suture, suture placed at the posterior third of uropods, numerous small spines along the suture.

Great chelae short and stout, almost twice as long as broad; propodus with one row of large tubercles, and one or two rows of smaller tubercles along the upper margin, lower margin with a tuberculate carina posteriorly, and a smooth carina anteriorly, cutting edge with two large and several smaller tubercles; dactylus short and stout, upper margin smooth or punctate, one or two large and several small tubercles along the cutting edge. Carpus and merus each with a row of tubercles along the upper margin.

Posterior pleurobranch long and well developed.

Habitat.—Victoria: Beech Forest, Otway Ranges, Ferntree Gully.

Types in the National Museum, Melbourne.

In a previous paper (2) this species was confused with two other species, under the name *E. fossor* Erichson.

Specimens received from Smithton, Tasmania, were taken as typical *E. fossor,* but material received later from the Tasmanian Biological Survey contained examples of the true *E. fossor.* These specimens are quite distinct from the Smithton examples. In a later paper (4) *E. fossor* was re-described and the Smithton example described as *E. ignotus.*

Comparison of the larger series of Tasmanian specimens with Victorian specimens has warranted the reinstating of *E. fultoni* for the Victorian species.

Readily separated from *E. ignotus* and *E. fossor* by the form of the squame of the second antennae, the rostrum, and the sternal keel.

Engaeus marmoratus sp. nov.
Plate X, Fig. 7.

Length of average adult specimen 60 mm.

Rostrum broad, reaching almost to base of third segment of first antennae, apex sharp and upturned; carinae sharp, carried well back on to carapace.

Squame of second antennae long and sharply pointed, inner lobe short, broad posteriorly. Interantennal spine large and broad, somewhat triangular, lateral margin serrated. Exopod of third maxillipedes long and slender.

Sternal keel slender and sharp, serrated; second and third pairs of lateral processes with a small round opening, fourth pair large, deeply grooved; processes between fourth pereopods long and stout.

Telson narrowly cone-shaped, almost as long as the uropods, with a spine on each lateral margin; inner rami of uropods rounded, with a sharp spine on outer lateral margin, each divided by a longitudinal median carina ending in a sharp spine near posterior margin; outer rami rounded, with a spine on outer lateral margin above the transverse suture, each divided by a longitudinal median carina, ending in a spine at transverse suture, the suture placed at the posterior third of ramus, numerous small spines along the suture.

Great chelae punctate and setose; propodus more than twice as long as broad, with one row of small tubercles on upper margin, lower margin smooth, several small tubercles along cutting edge of propodus; dactylus long and slender, a smooth carina along upper margin, several small tubercles along the cutting edge. A dense area of long stout setae on upper and lower surfaces of propodus and dactylus. Carpus and merus each with a row of tubercles along upper margin.

Posterior pleurobranch long and well developed.

Habitat.—Victoria: South Buchan (E. Clark).

Types in the National Museum, Melbourne.

Near *E. fultoni,* Sm. & Sch., but separated particularly by the great chelae and the sternal keel.

Engaeus orientalis sp. nov.
Plate X, Fig. 8.

Length of average adult specimen 58 mm.

Rostrum broad, reaching almost to base of third segment of first antennae, apex sharp and upturned, carinae sharp, reaching almost to apex, carried well back on to carapace.

Squame of second antennae long and slender, with a long sharp terminal spine, inner lobe slender. Interantennal spine short and broad, apex rounded. Exopod of third maxillipedes short and stout.

Sternal keel broad, more or less bluntly raised; first three pairs of lateral processes obsolete, fourth pair small, deeply grooved, processes between fourth pereopods long and slender.

Telson narrowly cone-shaped, almost as long as uropods, with a spine on each lateral margin near the posterior margin; inner rami of uropods rounded, each with a sharp spine on outer lateral margin, each divided by a longitudinal median carina ending in a sharp spine near posterior margin; outer rami rounded, each with a spine on outer lateral margin above the transverse suture, each divided by a longitudinal median carina ending in a spine at transverse suture, the suture placed at the posterior third of ramus, several small spines along the suture.

Great chelae smooth or setose; propodus twice as long as broad, upper margin with a few small tubercles posteriorly, smooth anteriorly, lower margin smooth, several small tubercles along the cutting edge; dactylus short and stout, upper margin smooth, one large and a few small tubercles along the cutting ege. Carpus and merus each with a row of small tubercles along the upper margin.

Posterior pleurobranch rather long and well developed.

Habitat.—Victoria: Cann River Valley (J. B. Ponder); Scanlon's Creek; Orbost (E. Clark).

Near *E. marmoratus* sp. nov., but readily separated by the form of the great chelae and the sternal keel. Some of the specimens have the great chelae covered with numerous tufts of long stiff setae.

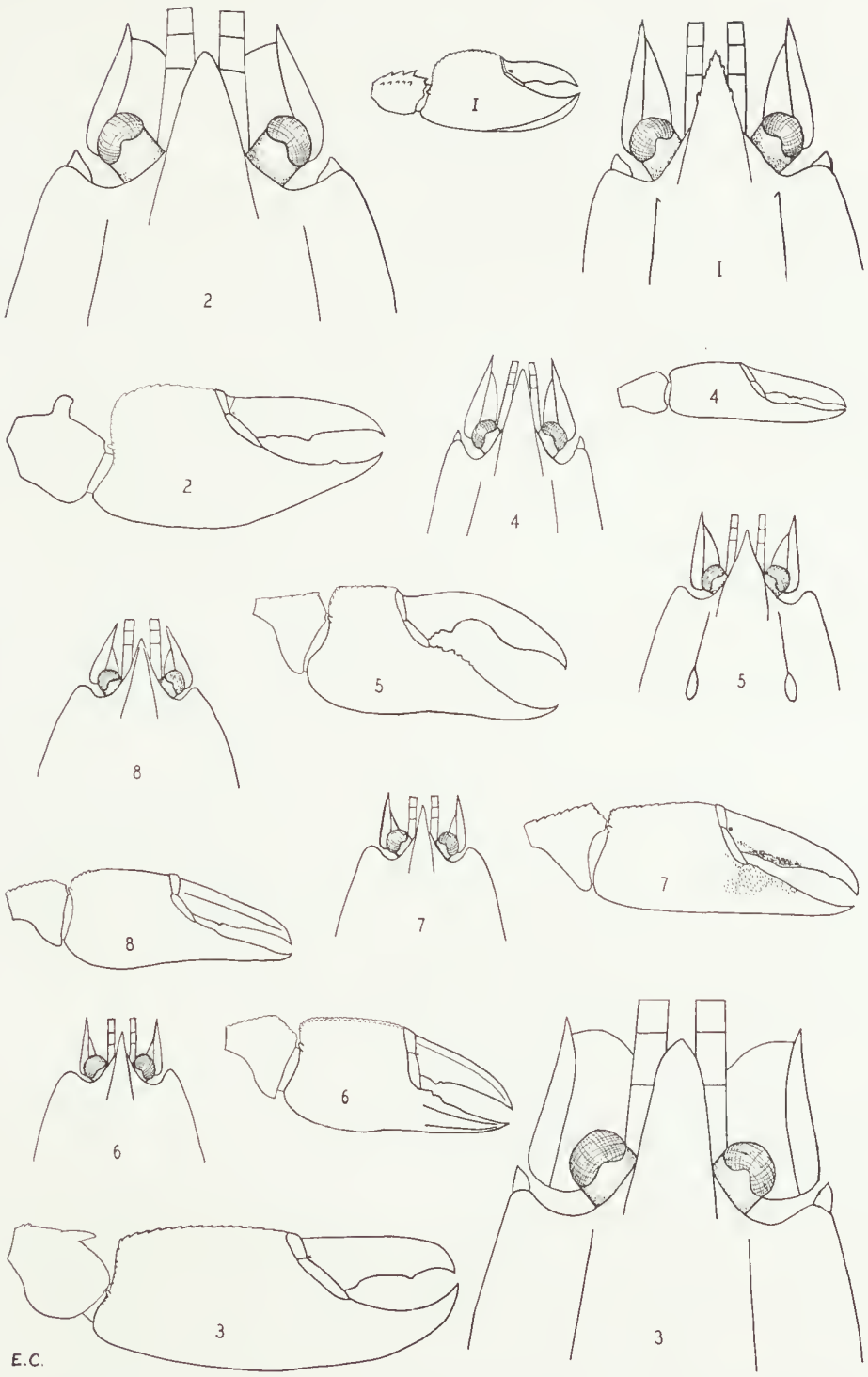
Bibliography.

1. Calman, W. T. Notes on a Crayfish from New Guinea. Ann. Mag. Nat. Hist., viii. (8), 1911, p. 366-368.
2. Clark, E. The Freshwater and Land Crayfishes of Australia. Mem. Nat. Mus., Vict., x, 1936, pp. 5-58, pls. i-xi.
3. Clark, E. Notes on the Habits of Land Crayfishes. Vict. Nat., liii, 1936, pp. 65-68.
4. Clark, E. Tasmanian Parastacidae. Papers & Proc. Roy. Soc. Tasmania, 1938, pp. 117-127, pls. xii-xiii.
5. Erichson, W. F. Uebersicht der Arten der Gattung Astacus. Arch. f. Naturg., xii, 1846, pp. 86-103.
6. Gray, J. E. New Species of the Genus *Astacus*. Eyre's Journ. Exped. Disc., Central Australia, i, (Appendix), pp. 407-411, pl. 3.
7. Hess, W. Beitrage zur Kenntniss der Decapoden-Krebse Ost-Australiens. Arch. f. Naturg., xxxi, 1865, p. 164, pl. vii, fig. 17.
8. Nobili, G. Ann. Mus. Civ. St. Nat. Genova, xl, 1899, p. 244.
9. Nobili, G. Boll. Mus. Zool., Torina, 1903, xviii, p. 1.
10. Roux, J. A propos des genres *Astaconephrops* Nobili et *Cheraps* Erichson. Zool. Anz. Leipzig, 37, 1911, pp. 104-106.
11. Roux, J. Nouvelles especies de decapodes d'eau douce provenant de Papouasie. Leyden Museum Notes, xxxiii, 1911, pp. 81-105, figs. 2-5.
12. Smith, G. The Freshwater Crayfishes of Australia. Proc. Zool. Soc. Lond., 1912, pp. 144-170, pl. xiv-xxvii.
13. Smith, G., and Schuster, E. H. J. The genus *Engaeus*, or the Land-Crayfishes of Australia. Proc. Zool. Soc. Lond., 1913, pp. 112-127, pl. xii-xxvii.
14. von Martens, E. Uberblick der neuhollandischen Flusskrebse. Monatsber. Akad. Wiss., Berlin, 1868, pp. 615-619.

PLATE X.

Chelae and parts of cephalothorax.

Fig. 1. *Cherax barretti* sp. nov.
2. *C. rotundus* sp. nov.
3. *C. davisi* sp. nov.
4. *Geocharax laevis* sp. nov.
5. *G. falcata* sp. nov.
6. *Engaeus fultoni* Sm. & Sch.
7. *E. marmoratus*, sp. nov.
8. *E. orientalis* sp. nov.



Freshwater and Land Crayfishes; Chelae and parts of Cephalothorax

THE CAROLINE STONY METEORITE.[1]

By F. L. Stillwell, D.Sc.

Plate XI.

The meteorite, which looks like a piece of ironstone, was picked up by Mr. S. McEachern at the site of a blackfellows' camp about four miles north of Caroline, near the half-mile stretch of the Glenelg River which is within the South Australian border not far from the mouth of the river. A fragment of ironstone is an unusual object on extensive Tertiary limestone plain where the meteorite was found. Mr. McEachern gave it to Mr. R. A. Keble, of the National Museum, Melbourne, who recognized that it was probably a stony meteorite.

The weathered condition of the meteorite indicates that it did not fall in recent years, and since it was found at the site of a blackfellows' camp, it may have been carried there by aborigines.

The stone would not attract attention on the basaltic areas in Victoria, and this may be a reason why no stony meteorite has yet been found in Victoria.

The Caroline meteorite (Pl. XI, fig. 5) is rusty in colour, roughly rectangular in shape, and approximately 8 x 8 x 6 cm. in size; after slicing, the specimen, with detached chips, weighed 800 gm.; specific gravity, 3·40. The thin outer skin is the colour of limonite, unlike the black skin of fresh stony meteorites. One surface, where the skin was broken away, has a fractured appearance; the opposing surface, where the skin is partly preserved, displays shallow "thumb-mark" depressions which are characteristic of many meteorites. Other surfaces are relatively smooth. A hand lens reveals small fused and slaggy patches.

A vein of limonite 0·5 cm. wide (Fig. 5, lower left-hand corner) forms a slight ridge on a surface which is otherwise smooth. This vein, together with the even impregnation of iron oxide on both sides of the ridge simulates banded ironstone, but it is probably an oxidized seam of nickel-iron or pyrrhotite. After polishing, surfaces reveal numerous small secondary limonite veins formed during weathering.

In several places, irregular cracks up to 4 cm. long penetrate

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some distance below the surface; they are independent of the secondary limonite veins and were probably developed during the flight of the meteorite through the atmosphere.

Examination was confined to microscopical study of thin sections and polished surfaces, together with some chemical tests. No quantitative chemical analysis was undertaken since oxidation of much of the nickel-iron and pyrrhotite prevents satisfactory separation into magnetic and non-magnetic fractions, which is the initial step in chemical analysis of stony meteorites.

Examination in Transmitted Light.

Thin sections show the Caroline meteorite is a veined bronzite olivine chondrite.

Numerous chondrules, both monosomatic and polysomatic, are distributed through a crystalline matrix of olivine and pyroxene with small amounts of pyrrhotite and nickel-iron, scattered minute grains of chromite and rare interstitial areas of merrillite. Some chondrules are sharply defined and more or less spherical; others more irregular in shape appear to merge into the groundmass or have their outlines obscured by dense iron-staining. One monosomatic chondrule consists of a single grain of olivine 1 mm. in diameter. The polysomatic chondrules are usually aggregates of olivine crystals or of olivine and pyroxene. One of the clearest examples is a spheroid 1·7 mm. in diameter, formed largely of radiating prisms of bronzite which appears granular between crossed nicols, owing in part to intergrown monoclinic pyroxene; others consist of bronzite without the fan structure. One is composed of olivine grains separated by fine granular material including olivine, pyroxene and merrillite. Another, which is finely granular, contains minute specks of chromite and is made conspicuous by a rim of coarsely crystalline olivine and pyroxene.

Both orthorhombic and monoclinic pyroxenes are present. In sections normal to the optic axis, the orthorhombic pyroxene gives an interference figure in which the hyperbola is practically a straight line and the optical sign is indeterminate; the optic axial angle is, therefore, approximately 90° and the mineral is bronzite, not enstatite nor hypersthene. The monoclinic pyroxene has extinction angles up to 27°, indicating clino-bronzite rather than diopside.

The matrix is wholly crystalline; coarse crystals of olivine are in considerable excess over crystals of pyroxene; the

grain-size is, however, variable. Many of the olivine crystals are iron-stained and some contain clusters of minute opaque inclusions some of which proved, in reflected light, to be nickel-iron and pyrrhotite.

Occasionally very minute particles of reddish brown isotropic chromite form inclusions in both pyroxene and olivine. Small irregular plates of merrillite (1), a sodium calcium phosphate, occur interstitially between crystals of olivine and pyroxene. These plates are clear and colourless and have very low polarization colours; they are uniaxial and negative, with a refractive index a little lower than that of olivine. Merrillite is attacked by dilute nitric acid, and when a little powdered meteorite, from which the more highly magnetic fraction has been extracted (the bulk of the powder can be lifted by a strong magnet), is treated with dilute nitric acid for five minutes, the solution gives reactions for both calcium and phosphorus. These tests do not distinguish between phosphorus derived from merrillite and phosphorus derived from oxidized nickel-iron. Dr. A. B. Edwards determined the amount of P_2O_5 extracted in this way to be 0·21 per cent., and the total amount of P_2O_5 in the fraction to be 0·48 per cent. Occasional small, clear, interstitial particles of low refraction and birefringence are attributed to felspar; they are biaxial and positive, sometimes show cleavage and one shows traces of lamellar twinning. A green secondary mineral in one of the limonite veins is either a chloritic or serpentinous decomposition product of the silicates. Another vein of limonite has a core of undetermined clear, colourless, secondary mineral with a low refractive index and very low birefringence.

Examination in Reflected Light.

Primary minerals recognizable on polished surfaces of the meteorite include small grains of nickel-iron, pyrrhotite and chromite disseminated among the silicates; in addition, trevorite and limonite, are present as products of weathering.

Nickel-Iron. The largest grain of nickel-iron measures 0·43 x 0·23 mm. and is comparable in grain-size with the olivine. Oxidation of nickel-iron has progressed inwards from the surface and, when incomplete, a core with a corroded outline is surrounded by limonite; grains initially large may be represented by one or more particles of nickel-iron in a large area of limonite (Fig. 1); some small particles of nickel-iron, however, have a mere thin rim of limonite, and a few are

free from oxidation. Nickel-iron visible on polished surfaces does not occupy more than 0·3 per cent. of their area, but this figure would be much greater if slices were taken from the core of the meteorite, instead of from the marginal zone as has been done to avoid undue damage to the specimen. The original amount of nickel-iron, however, was probably not greater than that of pyrrhotite.

Nickel-iron, which appears bright white on the polished surface, is readily attacked by nitric acid and the solution so obtained gives microchemical reactions for nickel with dimethylglyoxime. Etching with 2 per cent. picric acid in alcohol reveals the internal structure and composition of the grains; kamacite is more readily attacked than taenite or schreibersite. Occasionally the kamacite grains enclose thin laminae which are less readily attacked and are presumably taenite; some thicker laminae consist of eutectoid mixtures of kamacite and taenite. Kamacite grains are often surrounded by a thin film of more resistant mineral (Fig. 2), probably taenite, but in one instance the proportions are reversed, the taenite rim exceeding the kamacite core in amount. In some grains an unattacked particle is attached to the kamacite (Fig. 4). Several of these chemically resistant particles were large enough to scratch with a needle; all but one were malleable, and may be regarded as taenite; one is brittle and is, therefore, schreibersite. A rare, internal, irregular intergowth with kamacite may also be schreibersite.

In some grains the progress of oxidation has been arrested at a lamina of taenite, other grains coated with a film of taenite have escaped oxidation in many cases. The taenite film may be partially separated from the kamacite by a layer of limonite, and even in completely oxidized grains, there are occasionally traces of marginal taenite.

An attempt was made to verify the presence of schreibersite by determining the phosphorus content of the more highly magnetic fraction of a sample of powdered meteorite. The highly magnetic fraction contained particles of nickel-iron, and limonite, some pyrrhotite and trevorite, and small quantities of transparent minerals; its P_2O_5 content, determined by Dr. A. B. Edwards on a sample weighing 0·15 grain, was 0·47 per cent. This percentage is higher than the average figure for stony meteorites, but is practically the same as that (0·48 per cent. P_2O_5) for the fraction unattracted by the magnet. The close approximation of the two percentages, together with the great impurity of the magnetic fraction, suggests that the oxidized minerals include some phosphate; and since

schreibersite, merrillite and possibly apatite are the only likely compounds of phosphorus in the unaltered meteorite and since merrillite is relatively unaltered, it seems likely that such phosphate as is associated with limonite has been derived from phosphide in the nickel-iron. There is thus an indirect suggestion that the residual nickel-iron contains phosphorus in sufficient amount for the presence of the phosphorus-rich constituent schreibersite.

Pyrrhotite. Pyrrhotite appears in the section as small irregular brownish-cream grains of variable size; they are magnetic, strongly anisotropic, and resistant to nitric acid, but tarnish slowly with caustic potash. In appearance and behaviour they are identical with pyrrhotite from other sources. Short's statement (2) that troilite, the iron sulphide in meteorites, is attacked by nitric acid with effervescence, was confirmed by a test on troilite in a polished surface of the Henbury meteoritic iron. Troilite occurs in iron meteorites in a matrix of metallic iron, and has frequently been reported in stony meteorites. Allen, Crenshaw, Johnston and Larsen (3) pointed out that troilite is the end member of a series of solid solutions of iron and sulphur known as pyrrhotite, and that stony meteorites probably contain ordinary pyrrhotite. Examination in reflected light determines that the sulphide in the Caroline meteorite is indistinguishable from pyrrhotite.

Numerous small particles of pyrrhotite occupy about 3 per cent. of the area of the polished surfaces, and are generally isolated in the silicates from the scarcer particles of nickel-iron. In a few instances pyrrhotite is in partial contact with nickel-iron or limonite derived from nickel-iron (Fig. 1). In rare cases minute particles of pyrrhotite are enclosed in nickel-iron.

Pyrrhotite, though much less weathered than nickel-iron, presents all stages of decomposition into limonite; decomposition proceeds, not so much from the external surface as along fractures, where veins of limonite develop; all stages of alteration are represented, from a pyrrhotite grain transversed by a network of limonite veins, to a limonite mesh containing minute particles of pyrrhotite. Traces of this meshwork remain after oxidation is complete and distinguish an area of limonite derived from pyrrhotite from one derived from nickel-iron.

Chromite. Grains of chromite are much fewer than those of pyrrhotite. One of the larger grains measures 0·18 x 0·10 mm. Occasional minute particles not more than 0·006

mm. wide are embedded in the silicates or in interstices between them and correspond to the small particles of chromite recognized in transmitted light. The grains are hard, resistant to weathering, and distinguished on polished surfaces by their colour, greyish white with a tinge of brown; they are isotropic and resistant to all standard etching agents. Their shape is at times suggestive of octahedral outlines. They are free from inclusions except in rare instances when they appear to enclose small particles of pyrrhotite or of a silicate; narrow veins of iron-oxide occasionally extend from surrounding areas into a grain of chromite, sometimes dying out within the limits of the crystal, sometimes cutting through it. Pyrrhotite when in contact with chromite appears to be moulded on it. The edges of small particles excavated from the polished section and examined in transmitted light, are translucent and dark green merging in places into brownish. Normal chromite grains are brownish in transmitted light, and the green tint may indicate an isomorphic mixture of chromite with picotite or hercynite.

The presence of chromium was confirmed by a qualitative "spot" test with diphenylcarbazide. Powdered meteorite was fused on a platinum wire in a bead of potassium carbonate and potassium chlorate; the bead was dissolved in water, the solution concentrated, and then acidified with two drops of 1:1 H_2SO_4. Two drops of a 1 per cent. alcoholic solution of diphenylcarbazide added to this solution gave the violet-blue colouration characteristic of chromium in the absence of mercury and molybdenum, neither of which is present in the meteorite. The same test applied to particles of chromite excavated from the section gave a similar positive result.

Trevorite. Weathering has produced numerous narrow, anastomising veins of limonite in addition to isolated areas of limonite derived from pyrrhotite and nickel-iron. Many of these veins are extremely narrow, others are 0·2 mm. wide, and still wider areas of limonite occur at the intersection of veins and in other localized areas. Colloform banding in many veins is indicated on polished surfaces by different shades of grey assumed by different varieties of limonitic hydroxides, and in places the banding is accentuated by very thin lines of a whiter mineral, possibly hematite. Trevorite, $NiO.Fe_2O_3$, sometimes forms part of the banding (Fig. 3), and small massive areas within the vein; trevorite was also observed as a small crystal attached to a limonitic pseudomorph after nickel-iron.

Trevorite was established as a mineral species by Walker

(4) and shown to be a common product of oxidation of meteoric irons by Shannon (5). Its reflective power is higher than that of limonite or chromite, and on the polished section its colour is greyish-white with a pinkish tint. It is isotropic, slightly harder than limonite, and does not have internal reflections. It resembles magnetite except perhaps for its pinkish tinge and for its obviously secondary character. It is negative to nitric acid and other standard etching agents, but is slowly attacked by concentrated hydrochloric acid. Particles are magnetic and when dissolved in hot hydrochloric acid give reactions for nickel with dimethylglyoxime.

Occasionally the colloform banding including trevorite is cut transversely by newer narrow limonite veins (Fig. 3). In some instances margins of areas of massive trevorite are corroded by limonite, and in places the edges of trevorite bands are separated from limonite by extremely narrow whitish zones which may possibly be hematite. These phenomena suggest that the formation of trevorite is a phase in the oxidation of nickel-iron which will ultimately be converted into limonite with complete removal of nickel. The ratio of trevorite to limonite is small, just as is the ratio of nickel-iron to silicates.

References.

1. E. V. Shannon and E. S. Larsen. Merrillite and Chlorapatite from Stony Meteorites. Amer. Journ. Sci., 5th ser., vol. IX, 1935, pp. 250-260.
2. M. N. Short. Microscopical Determination of the Opaque Minerals. U.S.A. Geol. Surv., Bull. 825, p. 74, 1931.
3. E. T. Allen, J. L. Crenshaw, J. Johnston, and E. S. Larsen. Mineral Sulphides of Iron. Amer. Journ. Sci., 33, 1912, pp. 212-213.
4. T. L. Walker. Trevorite, a Distinct Mineral Species. Contrib. to Can. Min., Univ. Toronto, Geol. Ser., No. 16, pp. 53-54, 1923.
5. E. V. Shannon. The Oxidation of Meteoritic Irons. Proc. U.S.A. Nat. Mus. 72, art. 21, 1927.

Plate XI.

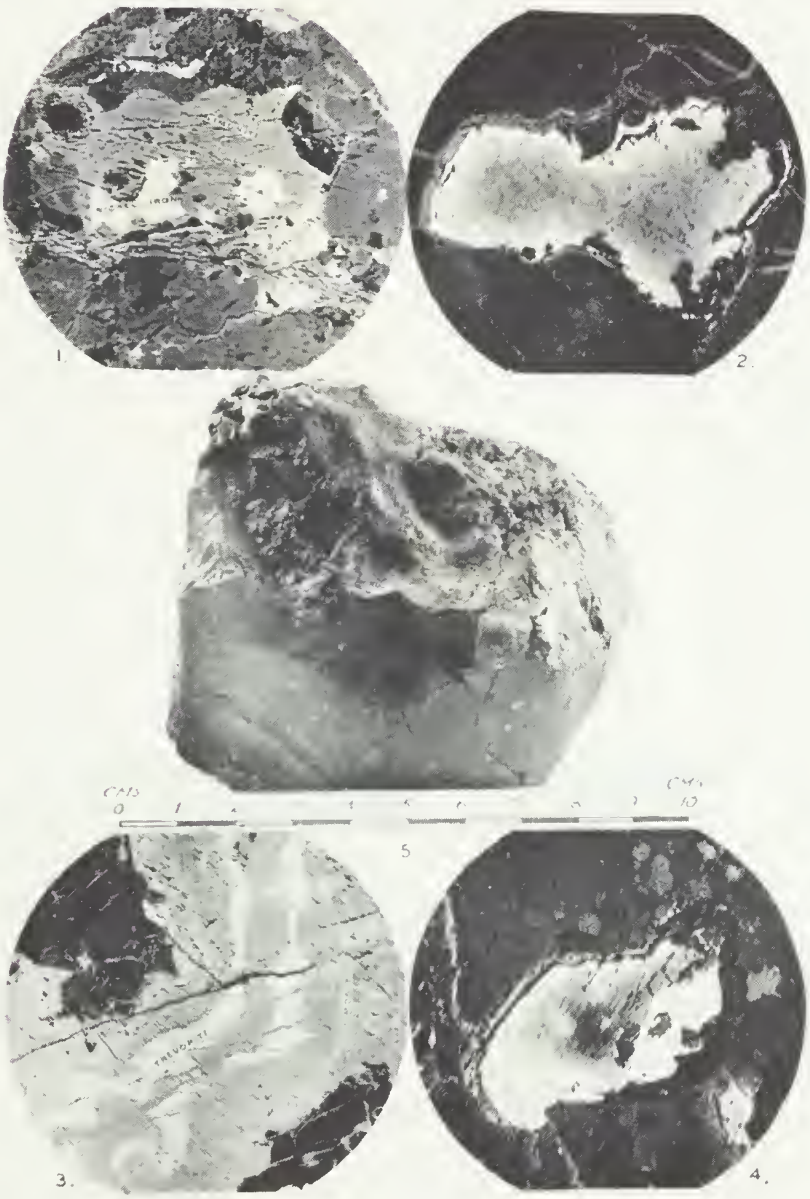
Fig. 1. Two residual cores of nickel-iron in an area of limonite in contact with a particle of pyrrhotite. Mag. 110.

2. Grain of nickel-iron, etched with 2 per cent. picric acid in alcohol; the darkened area of kamacite is surrounded by an unattacked, marginal film of taenite. Mag. 400.

3. Trevorite in a limonite vein showing colloform banding. Trevorite is cut by later narrow veins of limonite. Mag. 110.

4. Grain of nickel-iron, etched with 2 per cent. picric acid in alcohol, composed of a darkened area of kamacite with a partial marginal film of taenite and an unattacked particle of taenite. Mag. 400.

5. The Caroline stony meteorite, showing pitted and fractured surfaces in the upper part and a vein of oxidized nickel-iron in the lower left corner.



The Caroline Meteorite

THE BOND SPRINGS STONY METEORITE.

By George Baker, M.Sc., and A. B. Edwards, Ph.D.

Plate XII, Figs. 1-4.

Introduction.

The stony meteorite (aerolite) described herein was presented to the Geology Department Museum of the University of Melbourne in June, 1931, by Mr. F. H. McK. Grant. It is reported to have been found near the Overland Telegraph Line, five miles south of Six Mile Creek, and about ten miles west of Mt. Sir Charles; this locality is north of the MacDonnell Ranges, about fifteen miles from Alice Springs, and three miles west of the Bond Springs Station, Lat. 23° 30′ S., Long. 133° 50′ E. Mr. Grant, to whom the meteorite was given in August, 1898, states that it was found on the surface of the ground when Oodnadatta was the railway terminus. The line to Oodnadatta was opened in 1891, and it is, therefore, assumed that the specimen was collected between 1891 and 1898.

There is no record of an observed fall of meteorites in this area, which was seldom visited by Europeans until recent years. The fresh appearance of the specimen suggests that it is not very ancient, although weathering is slow in this arid region.

No records of aerolites from Central Australia are included in Fletcher's index to meteorites represented in the British Museum collection (6), nor in Hodge-Smith's list of Australian meteorites (7), and Mr. Hodge-Smith, in a communication to the writers of this paper, states that the specimen here described is the first known Central Australian aerolite. We suggest that it be designated the Bond Springs Aerolite to distinguish it from the Alice Springs Pallasite (7, p. 70) which was found in the same district. The meteorite was examined by transmitted and by reflected light.

General Description.

The aerolite is of the enstatite-olivine chondrite type. It is free from fracture or other damage, and although small, is apparently complete. The outer skin, which is relatively smooth and free from pits or "thumb-marks," is dull, dark brown to black and less than 0·25 mm. thick; occasional

small bright metallic grains are visible. The interior, which is gray with occasional brown areas in the vicinity of the enclosed metallic grains, appears to be little altered.

Before slicing, the specimen measured 26 x 15 x 13 mm. and weighed 6·18 grams; specific gravity 3·531 at 14° C. After sectioning and polishing, only 2·03 grams remained.

The specimen was too small to permit chemical analysis, but a micrometric analysis based on 21 traverses across a polished surface indicates the proportions of the main constituents set out below.

	Volume %	*Assumed Specific Gravity*	*Calculated Weight* %
Fe-Ni metal	8·3	7·5	17·3
Pyrrhotite	3·7	4·6	4·7
Silicates	87·9	3·2	77·9
Chromite	0·1	4·4	0·1

In the table shown these calculated percentage weights are compared with similar percentages calculated from chemical analyses of other aerolites.

	Fe-Ni Metal %	*Iron Sulphide* %	*Silicates* %	*Specific Gravity*
1	17·3	4·7	77·9	3·53
2	15·2	5·5	79·3	3·52
3	11·1	4·4	84·5	3·53
4	18·5	5·2	76·3	3·61
5	13·2	5·7	81·1	3·54, 3·55, 3·59, 3·62
6	13·4	3·4	83·2	3·59
7	9·3	5·5	85·2	3·62
8	8·0	6·5	85·5	—
9	19·6	4·8	75·6	3·59
10	18·9	5·7	75·4	—
11	0·4	4·0	95·6	3·50
12	7·0	6·0	87·0	3·51
13	9·8	7·3	82·9	3·45
14	7·2	6·4	86·4	3·48

1. Bond Springs Meteorite, Alice Springs District, Central Australia.

2. Suwahib, Arabia (3); 3. Hedjaz, Arabia (3); 4. Cronstad, Orange River Colony, South Africa (3); 5. Morven, New Zealand (8); 6. Rosebud, Texas, U.S.A. (2); 7. Rangala, India (4).

8. Eli Elwah, N.S.W. (7); 9. Elsinora, N.S.W. (7); 10, Gilgoin, No. 7, N.S.W. (7); 11. Karoondah, South Australia (7); 12. Lake Brown, Western Australia (7); 13. Narellan, N.S.W. (7); 14. Warbreccan (Tenham), Queensland (7).

The nickel-iron percentage in the Bond Springs Aerolite is considerably higher than it is in five out of the other seven Australian examples. The percentage of iron sulphide approximates that for the other meteorites but tends to be lower than in most of the Australian examples. The table indicates the variability in the metal content of aerolites.

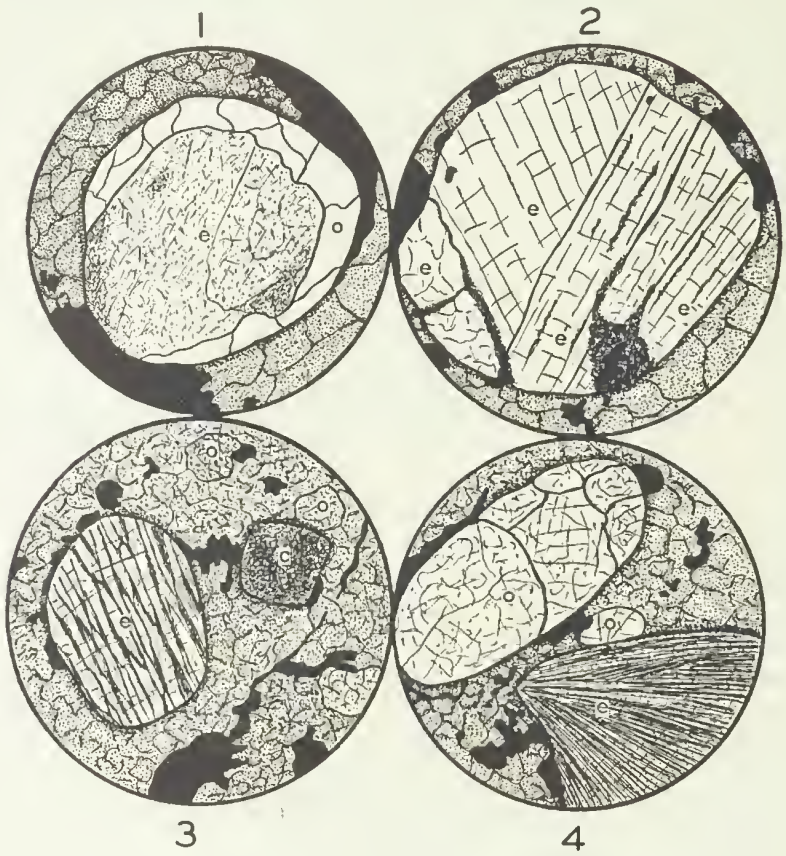
The Bond Springs Aerolite is crystalline, with a microporphyritic structure, numerous chondrules of microscopic dimensions, and occasional small individual crystals in a finer-grained matrix. Most porphyritic constituents are under 1 mm. in diameter, the largest section observed measuring 1·50 x 0·75 mm. The majority of the chondrules are not much larger than the groundmass constituents, and many of them are unbroken. The metallic minerals rarely encroach upon the chondrules, and occur as scattered grains and lobate patches throughout the base, often partially outlining chondrules and larger crystals.

The most abundant minerals are enstatite, with (+) 2V = about 60°, and olivine; these two minerals form the chondrules, the greater part of the groundmass, and the occasional larger individual crystals. A little clinopyroxene, with extinction angles ranging from 6°-36° and (+) 2V > 45°, is associated with enstatite in a few chondrules and to a less extent in the matrix; presumably it is a diopsidic augite. Micrometric analysis indicates that Fe-Ni metal forms 17·3 per cent. by weight of the meteorite and pyrrhotite 4·7 per cent. Chromite occurs as occasional grains. In the fine-grained, more or less holocrystalline matrix, which is composed essentially of granular enstatite and olivine, one crystal of felspar was observed; it has lamellar twinning, undulose extinction, and an extinction angle of approximately 6° in the symmetrical zone, and it is possibly oligoclase, but may be more basic. In addition, there are occasional small patches of a mineral with low birefringence which may be devitrified glass or possibly maskelynite, a glass having the composition of basic labradorite, described from certain extra-Australian aerolites. Isotropic glass occurs in minute quantity in the matrix of one of the chondrules.

Chondrules.

Chondrules are very abundant; the thin section, no more than half an inch square, contains over thirty well-defined chondrules of circular, ovoid and irregular shapes. In structure, some resemble chondrules described from the

Morven (New Zealand) aerolite (8), and from the Rosebud (Texas, U.S.A.) aerolite (2), but a few are difficult to distinguish from the granular groundmass, owing to similarity in composition and in state of fracture.



Sections of Chondrules.

Black areas represent metal and pyrrhotite; dotted areas, silicates in the matrix.

1. Polysomatic composite chondrule; diameter, 0·2 mm. A ring of clear olivine grains (o) surrounds finely fibrous enstatite (e). 2. Polysomatic chondrule of sub-radiate enstatite crystals (e); diameter, 0·5 mm. Minute grains of dusty matter crowd portions of the cleavage lines and crystal boundaries. 3. On left, monosomatic chondrule of barred (laminated) enstatite (e); size 0·8 x 0·5 mm. On right, cryptocrystalline chondrule (c); diameter, 0·3 mm. Olivine grains (o). 4. Bottom right, monosomatic chondrule of radiating enstatite fibres (e); diameter, 0·5 mm. Top left, polysomatic chondrule composed of several olivine grains which extinguish in different positions; size, 0·7 x 0·4 mm.

Three main types of chondrules are present:—

(a) Monosomatic; composed of a single grain or crystal of enstatite or olivine.
(b) Polysomatic; consisting of several grains of one or more minerals segregated into conspicuous groups with glomero-porphyritic structure.
(c) Cryptocrystalline; with no determinable constituents or characteristic structures.

Monosomatic chondrules are barred or laminated, parallel bars of enstatite (or olivine) in optical orientation alternating with laminae of gray, dusty material. The granular structure of other monosomatic chondrules is due to the gray, dusty material occurring as regularly arranged patches throughout the single crystal composing the chondrule. These differences in appearance may depend on whether the chondrule has been sliced transverse or parallel to the laminae.

Varieties of polysomatic chondrules are more numerous. Some enstatite chondrules or sectors of chondrules consist of fine fibres radiating from one or more points; others consist of larger sub-radiate crystals. Some porphyritic chondrules are formed by several grains of olivine set in fine-grained indeterminate dusty material, or the dusty material may be absent and the grains of olivine crowded together, all extinguishing in different positions. Other chondrules consist of grains and fibres of enstatite in a fine-grained, gray base, or are made up of criss-cross fibres or fine-matted laths of enstatite in such a base. Composite chondrules contain both enstatite and olivine crystals in a microcrystalline to cryptocrystalline matrix; one consists of a core of fibrous enstatite surrounded by a ring of clear olivine grains, all components extinguishing in the same position.

The cryptocrystalline chondrules, which often display undulose extinction, may consist of crystallites of enstatite: they are the least numerous type.

Opaque Minerals.

A polished section in reflected light reveals nickel-iron, abundant pyrrhotite, scattered crystals of chromite, and occasional narrow veins of limonite. Intimately associated nickel-iron and pyrrhotite form irregular patches interstitial to the chondrules; they also occur as minute grains, 5 to 10 microns across, sometimes in well defined rows, enclosed in the silicates.

Before etching, the nickel-iron appears to be a uniform

mineral substance, creamy-white with a tinge of brown, but, on etching with a 2 per cent. solution of picric acid in alcohol, it is resolved into an intergrowth of kamacite (-nickel-iron), taenite (γ-nickel-iron), and an unidentified mineral.

Kamacite (6-8 per cent. Ni) constitutes the bulk of the nickel-iron; it is isotropic, magnetic and readily scratched with a needle. With nitric acid it effervesces and stains brown, and the resulting solution gives microchemical reactions for iron and nickel; the etched surface reveals grain boundaries and irregular lamellae of the unidentified mineral. Hydrochloric acid attacks the kamacite readily, with effervescence, and turns it black. Ferric chloride rapidly stains it brown, and it rubs to a slightly etched surface; mercuric chloride blackens the surface at once, but it rubs clean. Potassium cyanide and potassium hydroxide give negative results.

Taenite (25-40 per cent. Ni), which is also a creamy-white isotropic magnetic mineral, is distinguished from the kamacite by the fact that it is not etched rapidly by picric acid-alcohol solution nor by bromine water. Nitric acid slowly stains taenite brown, but does not cause effervescence. Other standard etching reagents give negative results, except mercuric chloride, which immediately blackens the taenite, but rubs clean.

Some doubt attaches to the determination of taenite in this meteorite, because the mineral under discussion occurs in grains (Pl. XII, figs. 1 and 2) and not lamellae; the possibility that it is the phosphide, schreibersite, cannot be neglected. A small grain of the mineral regarded as taenite was prised out with a drill and dissolved in nitric acid; it yielded positive reactions for iron and nickel. The iron may have come from associated pyrrhotite, but it is unlikely that the nickel came from this source, since repeated tests for nickel on grains of pyrrhotite gave negative results. The grain was too small to test for phosphate.

Determination of this mineral as taenite is strengthened by occasional dark cores (Pl. XII, fig. 1) identical with those observed in undoubted taenite; Vanick (12, p. 178) regards these cores as due to minute carbon particles, but Johnston and Ellsworth (9, p. 97) consider them to be dissolved phosphide.

The taenite frequently forms thin rims, 5 to 10 microns thick, around small areas of kamacite; similar rims are figured by Dunn (4) for the Rangala Meteorite. Occasionally

it forms fine intergrowths with kamacite; in some of these the mineral associated with the taenite etches more strongly than typical kamacite, and turns black (Pl. XII, fig. 3), but this blackened material usually grades into typical kamacite away from the intergrowth. There is no evidence to prove whether the more intense etching is due to the small size of the kamacite grains in the intergrowth, or to the presence in them of some substance such as a phosphide in solid solution. Apart from such intergrowths, taenite associated with kamacite occurs either as relatively large inclusions with fine saw-tooth edges (Pl. XII, fig. 1) or as thin films moulded on the margin of kamacite areas (Pl. XII, fig. 2).

Taenite is also intimately associated with pyrrhotite, often in subgraphic intergrowths over small areas (Pl. XII, figs. 5 and 6). Etching with picric acid and with bromine water shows that taenite is the only iron-nickel mineral in these intergrowths.

Unidentified Nickel-Iron Constituent. In addition to the two nickel-iron alloys just described, a third creamy-white opaque mineral occurs as irregular lamellae in the kamacite; it can be discerned only by etching with 2 per cent. picric acid in alcohol for about 30 seconds; see Plate XII, figs. 1, 2 and 4; in fig. 4 etching is complete; in figs. 1 and 2, the mineral is present in the kamacite to the same extent as in fig. 4, but in fig. 1 etching has not been carried far enough to make it visible, while in fig. 2 it is just beginning to appear. Bromine water does not etch it, but nitric acid attacks both kamacite and the lamellar mineral. Standard etching reagents produce similar results with the lamellar mineral and its kamacite host, so that the lamellar mineral is probably a nickel-iron alloy. Dunn (4, p. 269) notes similar lamellae in the Rangala Meteorite, and suggests that they may be due to twinning.

The lamellae are formed from coalescence of lens-shaped (?) ex-solution bodies, which, when they have failed to coalesce, occur in rows (Pl. XII, fig. 4). The lamellae are sub-parallel and somewhat curved; where the kamacite area narrows to a "waist," and then widens again, the lamellae tend to converge and to diverge correspondingly. Frequently a second, more weakly developed, series runs at right angles to the more prominent lamellae, and sometimes a third, still more weakly developed, series is inclined to the other two; presumably these lamellae lie in the more or less distorted cleavage directions of the kamacite host. It is highly probable

that these lamellae consist of a nickel-iron alloy somewhat richer in nickel than their kamacite host, which consists of α-iron; and they may be either residuals of γ-iron from the γ to α transformation, or possibly bodies of α_1-iron into which it has recently been shown (1) that such -iron may change on cooling.

Pyrrhotite. The pyrrhotite is creamy-brown in colour, magnetic, and polishes readily; it is slightly pleochroic and strongly anisotropic. With nitric acid, it is practically inert; a slight staining to a deeper brown results, but no effervescence or etching. Potassium hydroxide slowly stains the mineral dark brown; hydrochloric acid, ferric chloride and mercuric chloride give negative results. The mineral is therefore pyrrhotite, not troilite. According to Short (10, p. 74) and Farnham (5, p. 121) troilite effervesces vigorously with both nitric and hydrochloric acids, gives off fumes of hydrogen sulphide, and the surface of the mineral is etched; these results were confirmed by the authors for troilite in the Henbury Meteorite. Microchemical tests for nickel were negative.

The fact that the iron sulphide is pyrrhotite, not troilite, runs counter to generally accepted ideas about iron sulphides in meteorites. Hodge-Smith (7, p. 46) writes:—"A suggestion was made by Rose that troilite might be the mineral present in the irons and pyrrhotite in the stones. But the work of Ramsay and others appears to show clearly that troilite is the mineral characteristic of meteorites, whether they be aerolites or siderites." It is therefore significant that Stillwell (11) has also determined pyrrhotite in a stony meteorite from Caroline, South Australia, by microscopic examination of polished sections. Since determination of troilite in various stony meteorites appears seldom to be based on a microscopic examination by reflected light and chemical tests, the conception that troilite is the characteristic iron sulphide mineral of all meteorites is doubtful.

Chromite. Occasional gray isotropic crystals which resist all standard etching reagents are present. The larger grains are generally irregular in outline, but some of them and several smaller grains about 50 microns across have well marked octahedral shapes. This mineral is probably chromite. It is associated with transparent rather than with other opaque minerals, but the fact that nickel-iron and pyrrhotite are occasionally moulded about such grains indicates that it crystallized earlier than these minerals.

Limonite. Limonite due to weathering is present in very small amounts as occasional narrow seams which enclose small chondrules and infill cracks, but neither nickel-iron nor pyrrhotite have given rise to limonite.

References.

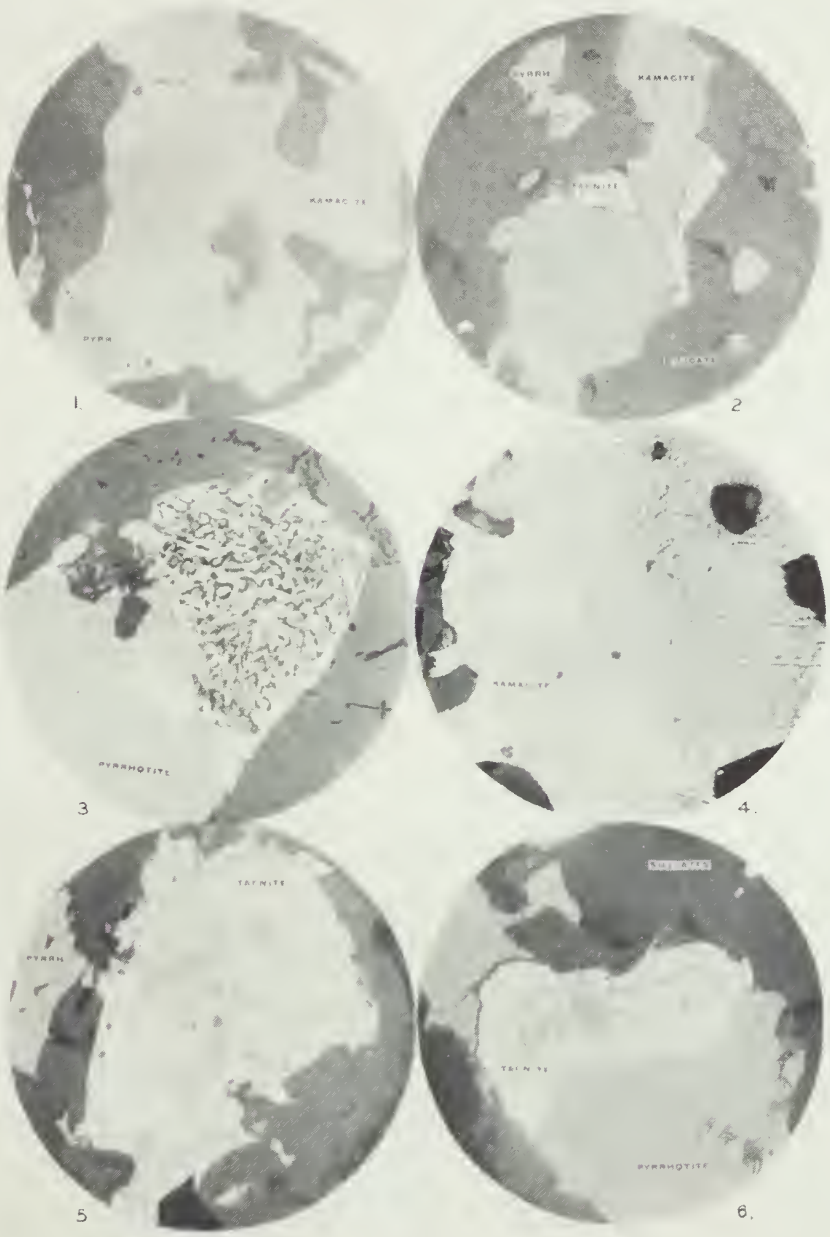
1. Bradley, A. J., and H. J. Goldschmidt. An X-Ray Investigation of the Iron-Rich Nickel-Iron Alloys. Journ. Iron Steel Inst., vol. cxl, No. II, 11, 1939.
2. Bullard, F. M. The Rosebud Meteorite, Milam County, Texas. American Mineralogist, vol. 24, No. 4, pp. 242-254, 1939.
3. Campbell Smith, W. A New Meteoric Stone from Suwahib, Arabia. Min. Mag. xxiii, pp. 290-304, 1932.
4. Dunn, J. A. The Rangala Meteorite. Records Geol. Surv. India, vol. 74, pp. 260-276, 1939.
5. Farnham, C. M. Determination of the Opaque Minerals. McGraw-Hill, 1931.
6. Fletcher, L. An Introduction to the Study of Meteorites. British Museum (Natural History) Guide Book, 10th edition, 1908.
7. Hodge-Smith, T. Australian Meteorites. Australian Museum Memoir, vii, 1939 .
8. Hutton, C. O. The Morven Meteorite; An Aerolite from South Canterbury, New Zealand. Min. Mag. xxiv, pp. 265-275, 1936.
9. Johnston, R. A. A., and Ellsworth, H. V. The Annaheim Meteorite. Trans. Roy. Soc. Canada, vol. xv, section IV, 1921.
10. Short, M. N. Microscopic Determination of the Ore Minerals. Geol. Surv. U.S.A., Bull, 825, 1931.
11. Stillwell, F. L. The Caroline Stony Meteorite. This Memoir, pp. 41-47.
12. Vanick, J. S. Microstructural Features of Several Meteorites. Trans. Amer. Soc. Steel Treatment, vol. 7, 1925.

Plate XII.

Microphotographs by reflected light of sections etched with 2 per cent. solution of picric acid in alcohol.

Fig. 1. Two areas of taenite (white) associated with kamacite; the lower taenite grain has a dark core, presumably of minute carbon particles or dissolved phosphide. Etched for 10 seconds. Mag. 250.

2. Two areas of taenite (white) associated with kamacite which is traversed by two sets of lamellae of an unidentified iron-nickel mineral. Etched for 20 seconds. Mag. 250.
3. Eutectic intergrowth of taenite (white) and kamacite (dark), fringing an area of pyrrhotite (grey). Etched for 10 seconds. Mag. 750.
4. Lamellae of unidentified iron-nickel mineral (white) in kamacite. Etched for 60 seconds. Mag. 350.
5. Eutectic intergrowth of taenite (white) and pyrrhotite (grey). Unetched. Mag. 500.
6. Eutectic intergrowth of taenite (white) and pyrrhotite (grey) fringing an area of pyrrhotite (grey). Etched for 10 seconds. Mag. 750.



The Bond Springs Meteorite

NOTES ON THE ARGENTINE ANT AND OTHER EXOTIC ANTS INTRODUCED INTO AUSTRALIA.

By John Clark,

Entomologist, National Museum of Victoria.

Figs. 1-3.

The genus *Iridomyrmex* has its main centre in Australia where there are eighty forms; it is represented by ten forms in South and Central America, three in India and four in Japan and adjacent Islands. Africa, Europe and North America contain no native forms.

At least two Australian species have been transported to other places. *Iridomyrmex glaber* Mayr has been recorded from some of the Pacific Islands, Malaya and India; and *Iridomyrmex rufoniger* Lowne from Samoa.

Two forms are known to have been imported in past years into Australia, *Iridomyrmex anceps* Roger from India and Malaya, and its variety *papuana* Emery from New Guinea, both recorded from the Northern Territory and Queensland. Neither of the two forms appears to be common as few examples are received amongst the many species collected in the areas concerned.

The latest introduction and addition to the Australian list, *Iridomyrmex humilis* Mayr, commonly known as the Argentine Ant, was first recorded from Buenos Ayres, Argentine, in 1868 and since that time it has been transported to most parts of the world.

The date of its arrival in Australia is unknown, but from the evidence gathered it was first noticed in Balwyn about ten years ago. No complaints or specimens were received until early in September, 1939, when a resident of Balwyn brought specimens to the National Museum to be identified, and sought assistance to clear the ants from his property.

This pest is now widely distributed throughout the world. It has been established in various parts of South America; Southern States of U.S. America, Madeira, South Africa, Portugal and Germany.

Writing in 1913 Newell, after five years study of the ant, says:—"From an unknown and little noticed insect this ant has developed into one of the foremost household pests in the world, and its ravages affect, directly or indirectly, the

majority of crops grown in the South. Former indifference to its movements has given way to concern at its approach . . . Just how much territory this ant will ultimately infest we can not foretell with accuracy from the data at present available. It is quite safe, however, to venture the opinion that the species will eventually spread over a considerable portion of the Southern States—certainly over all of the orange and sugar-cane belts, and perhaps over all of the cotton belt."

Referring to the small beginnings of the infestation he writes:—"The species had doubtless been introduced years before that time, but was gathering strength and establishing itself for a considerable period before its numbers become sufficient to attract attention. Since then it has increased from a few scattered and apparently insignificant specimens to armies and hordes numbering myriads of individuals. It has spread from a few blocks on the water front of the Mississippi River over practically the entire city, and has sent out vast numbers of colonists for hundreds of miles along the railways and waterways radiating from New Orleans. These pioneers have succeeded in founding scores of communities of more or less importance in the smaller cities and towns. Each of these communities is in turn furnishing its quota of migrants, and these are extending the affected territory in all directions from the original source of infestation. Thus, instead of the dispersion being from one source only, it is now taking place from hundreds of different points."

This is exactly the position with which we are faced in Victoria to-day. A number of comparatively small outbreaks in widely separated districts are developing apace, and unless drastic action is taken immediately to prevent the dispersion of the pest and concentrated effort given to exterminating the nests at present in existence, the whole of Australia will be faced with the same colossal expenditure that the American Government has had to meet in the past with little results to show for it.

Every effort must be made to exterminate this menace while there is still some possibility of success. Without the full co-operation of the Departments concerned, and the general public, little can be done. Whatever action is to be taken, it must be done at once.

To assist in the identification of this species, detailed descriptions and figures of the worker, female and male are given in the following pages.

FIG. 1.

Iridomyrmex humilis Mayr. Worker.

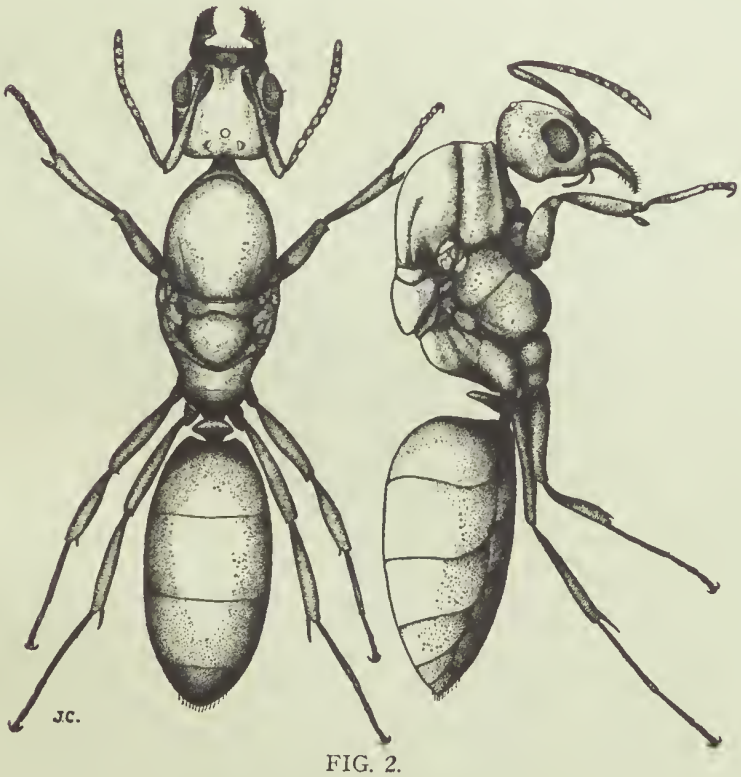


FIG. 2.

Iridomyrmex humilis Mayr. Female.

Iridomyrmex humilis Mayr

Figs. 1-4.

Hypoclinea humilis Mayr, Ann. Soc. Nat. Modena, iii, p. 164, 1868, ☿.
Hypoclinea (*Iridomyrmex*) *humilis* Mayr, Verh. Zool. Bot. Ges. Wien, xx, p. 959, 1870, ☿.
Iridomyrmex humilis, Emery, Zeitschr. f. Wiss. Zool., xlvi, p. 386, 1888.
Iridomyrmex humilis, Newell, Jour. Econ. Entom., i, p. 28, 1908; ibidem, pp. 174-192, figs. 1-4, pls. 5 and 7, 1909, ☿ ♀ ♂.
Iridomyrmex humilis, Arnold, Ann. S. Afr. Mus., xiv (1), p. 145, pl. iv, figs. 41-4a, 1915, ☿ ♀ ♂.

Worker. Length 2-3 mm. (Fig. 1).

Brown, antennae and legs yellowish brown, mandibles yellowish.

Smooth and somewhat shining, very finely, densely and superficially reticulate. Mandibles with small obsolete punctures.

Hair very sparse, greyish, erect, confined to the mandibles, clypeus and apex of gaster. Pubescence greyish, very fine and close lying, abundant but not hiding the sculpture.

Head longer than broad, much broader behind than in front, sides and posterior angles strongly convex, occipital border straight or feebly concave. Mandibles triangular, furnished with numerous small sharp teeth. Clypeus convex, high in the middle, anterior border projecting concave, the angles rounded. Frontal area indistinct. Frontal carinae as long as broad, not covering the antennal insertions in front. Scapes extend beyond the occipital border by one-fourth of their length; all segments of the funiculus longer than broad, gradually decreasing in length from first to tenth, apical as long as first. Eyes rather flatly convex, placed dorsally in front of the middle of the sides. Thorax almost two and one-fourth times longer than broad through the pronotum, slender. Pronotum one-fourth broader than long, strongly convex in all directions, pro-mesonotal suture sharply, but not deeply impressed. Mesonotum long and slender, not bordered on sides, strongly convex laterally, dorsum twice as long as broad; meso-epinotal suture deep and wide. Epinotum as long as broad, half as long as mesonotum, convex in all directions; in profile the dorsum of pronotum and mesonotum evenly convex, highest at pro-mesonotal suture, epinotum short and convex, rounded into the declivity. Node thin, scale-like, convex transversely, top edge sharp. Gaster twice as long as broad. Legs long and slender.

Female. (Deälated) Length 4·5-5·5 mm. (Fig. 2).

Colour and sculpture as in the worker.

Hair sparse but more abundant than on the worker. Pubescence longer and much more abundant.

Head very slightly longer than broad, slightly broader behind than in front, occipital border and sides straight, angles rounded. Mandibles larger, the teeth stronger and more numerous than in the worker. Scapes extend beyond the occipital border by one-fifth of their length. Eyes large and convex, occupying fully one-third of the sides. Ocelli large and convex, the two posterior at a sharp angle, facing sideways and outward. Thorax fully twice as long as broad. Pronotum almost hidden from above by the mesonotum, strongly convex in front. Mesonotum one-eighth longer than broad, sides and front strongly convex, parapsidal furrows sharply impressed.

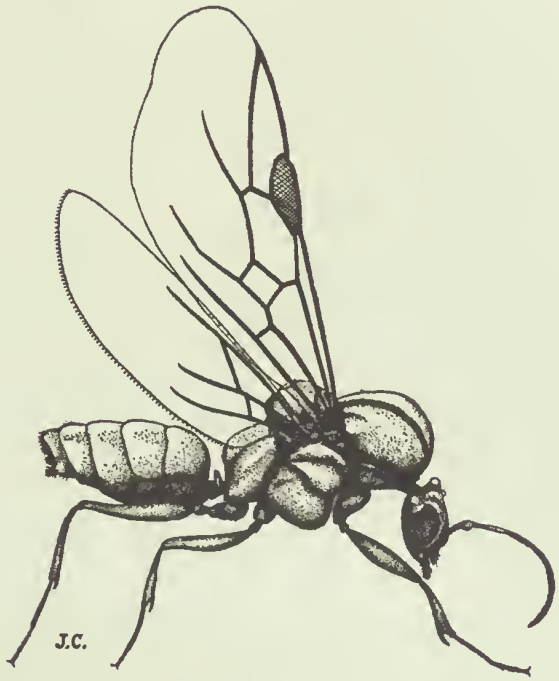


FIG. 3.

Iridomyrmex humilis Mayr. Male.

Scutellum as long as broad in front, somewhat cone-shaped, widest at base, overhanging the metanotum and epinotum. Metanotum narrow, ridge-like. Epinotum short, convex, rounded into declivity. Node scale-like, sharp above, strongly convex transversely. Gaster fully twice as long as broad. Legs long and slender.

Male. Length 3-4 mm. (Fig. 3).

Sculpture and pilosity as in the worker. Colour darker, the antennae and legs paler, more yellowish. Wings hyaline with a yellowish tinge, veins brown.

Head as broad as long, posterior angles rounded. Mandibles short, strongly curved, apex sharply pointed. Clypeus short, convex, broadly produced and convex in front. Antennal fovea deep. Antennae slender. Scapes one-third shorter than second segment of funiculus, first segment globular, longer than broad and broader than the other segments. Eyes large, flatly convex, occupying all of front half of sides. Ocelli large and prominent, the posterior pair forming strong angles on occipital border. Thorax large and robust, about one-third longer than broad. Mesonotum large and globular, one-fifth broader than long, overhanging the pronotum and head in front, parapsidal furrows deeply impressed. Scutellum large, hemispherical, shaped similar to that of the female, but higher. Epinotum broader than long, convex laterally; in profile mesonotum strongly arched from apex to base, overhanging pronotum and head. Scutellum twice as long as high, slightly overhanging behind, hiding metanotum. Epinotum level with mesonotum, straight in front, strongly convex and overhanging declivity behind, declivity concave. Node thicker than in female; in profile shorter and more bluntly pointed. Gaster shorter than thorax, slender, twice as long as broad. Genital valves external, small and rounded. Legs long and slender.

Locality.—Victoria: Widely distributed around Melbourne.

Apparently established first at Balwyn, about ten years ago, it is found now as far east as Dandenong (20 miles), and at Caulfield and St. Kilda. South-west it is found through Footscray to Williamstown (12 miles); northward it is found in Essendon and Brunswick.

This species cannot be confounded with any of the eighty native forms of the genus found in Australia.

In size and colour it is nearest to *Iridomyrmex darwinianus* Forel and its variety *fida* Forel. The anatomical structure, however, is different. In general appearance it is somewhat similar to *Tapinoma minuta* Mayr.

In his paper on this species, Newell gives a description of the ant written by the late Dr. W. M. Wheeler. The description of the female is misleading as Wheeler states that the *"thorax is nearly three times as long as broad,"* also that *"the scutellum projects above the mesonotum and epinotum."* Actually the thorax is little more than twice as long as broad and the scutellum overhangs the metanotum and epinotum. In front it is level with the dorsum of the mesonotum. Newell's figure

on page 182 in the second volume of the same journal shows the correct details.

The wing development of the female is weak, and in comparison with the size of the body the wings are small. They would be of little use for flight, but could possibly carry her a short distance from the original nest.

Following the information received regarding the presence of the ant at Balwyn, a tour of inspection was made of the district. This inspection was greatly facilitated by Mr. A. C. Thomas, a resident of Balwyn, and also Constable Barbour of the local Police Station. They supplied the approximate time of arrival and subsequent distribution of the ant in the district. The assistance of both gentlemen is greatly appreciated.

The ant was found to be abundant and active over an area of one mile square. Although the weather at the time was cold and unfavourable for ant life, this species was causing a lot of annoyance and inconveniece in the houses. As a house pest this is as bad as any of the previously introduced species and very much worse than any of the native species. It is, however, to be dreaded most as a serious pest to farmers, orchardists, poultrymen and bee-keepers.

A study of the distribution of the ant around Melbourne suggests that the species is spread by division of a large nest, the workers and females foraging far afield. The chief method of distribution appears to be by garden plants and pot plants taken from one locality to another, but the cartage of fire-wood and such material throughout the districts is also a big factor. The dispersion of the ant to Dandenong was traced to a nursery where plants had been transferred from Balwyn.

The nests are typical of most species of *Iridomyrmex,* but, generally, on a much larger scale. Nests were located in the ground, at the foot of fence posts, under bark on trees, in holes in trees, in the brickwork of houses and walls and in flower-pots in a plant nursery. One large nest was opened and from a section of the nest about eighteen inches long by four inches wide, thirty-seven females were obtained. As this nest extended the full length of the fence, about one hundred and eighty feet, it must have contained many hundreds of fertile females or queens.

Four species of *Iridomyrmex* had been plentiful where this ant now holds control, but at present there is no sign of them in these areas, although many were abundant where

the Argentine Ant had not appeared. It is interesting to note that in each country where *humilis* has been introduced it has displaced the native species.

The following is a list of the various ants found in the immediate neighbourhood, but not found in the area invaded by the Argentine Ant.

PONERINAE.

1. *Chalcoponera metallica* (Smith).
2. *Chalcoponera victoriae* Andre.

MYRMICINAE.

3. *Monomorium cincta* Wheeler.
4. *Pheidole yarrensis* Forel.

DOLICHODERINAE.

5. *Iridomyrmex rufoniger* (Lowne).
6. *Iridomyrmex domestica* Forel.
7. *Iridomyrmex nitidiceps* Andre.
8. *Iridomyrmex punctatissima* Emery.
9. *Technomyrmex albipes* (Smith).
10. *Technomyrmex jocosus* Forel.

FORMICINAE.

11. *Paratrechina (Nylanderia) obscura* (Mayr).
12. *Camponotus (Tanaemyrmex) consobrinus* (Erichson).

Of the above, the first two are beneficial as they destroy other insects. Both, however, sting severely and on that account are not always welcome in the garden. Numbers three and four are pests in the garden as both species are harvesting ants. They gather seeds which they carry to their nests as food. Numbers five and six are well-known house pests in most parts of Australia, but rarely appear in large numbers. Seven and eight are common in gardens but rarely enter houses. Nine is an introduced house ant which gives a lot of trouble, and as a house pest is almost as bad as the Argentine Ant; it is found in most of the coastal cities of Australia. It is generally known as the black house-ant. Ten and eleven rarely enter houses and are not abundant anywhere. Twelve is the common Sugar Ant, found abundant everywhere in Australia and Tasmania. It can be controlled with ease.

With very few exceptions, all the ants which cause serious trouble in houses and stores in Australia have been introduced

from abroad. As all are introduced with plants and merchandise, it appears that our Quarantine Laws relating to insect pests require a stricter application at all shipping ports and overseas postal parcels departments.

Following is a list of the ants introduced into Australia, showing their known distribution at present, and indicating the probable country of their origin.

PONERINAE.

1. *Odontomachus haematoda* (Linne). (Cosmopolitan in Tropics.)
   Northern Territory: Darwin, Point Charles.
   Queensland: Cooktown, Cairns, Townsville, Brisbane.
   North Western Australia: Broome, Derby.
   New South Wales: Sydney, Newcastle.
   Tasmania: Port Arthur.

MYRMICINAE.

2. *Cardiocondyla nuda* (Mayr). (India, Malaya.)
   Queensland: Cairns, Mackay, Brisbane.
   New South Wales: Sydney.
   Victoria: Melbourne, Irymple.
   Western Australia: Perth, Geraldton, Broome.
   South Australia: Adelaide.
3. *Cardiocondyla wroughtonii* Forel var. *hawaiensis* Forel. (Hawaii Island.)
   Queensland: Mackay.
4. *Monomorium (Parholcomyrmex) destructor* (Jerd). (India. Cosmopolitan in Tropics.)
   All States. Serious house and store pest.
5. *Monomorium (Parholcomyrmex) gracillimum* (Smith). (Cosmopolitan in Tropics.)
   Northern Territory: Darwin, Adelaide River.
   Queensland: Brisbane, Cairns.
   New South Wales: Sydney.
   Victoria: Melbourne.
   South Australia: Adelaide.
   Western Australia: Fremantle.
   House and store pest.
6. *Monomorium (Monomorium) floricola* (Jerd). (India. Cosmopolitan in Tropics.)
   Northern Territory: Darwin.
   Queensland: Cairns.
   House pest in North Australia.

7. *Monomorium (Monomorium) pharaonis* (Linn.). (Cosmopolitan in Tropics.)
   All States. Serious house and store pest.
8. *Pheidole megacephala* (Fabr.). (Cosmopolitan in Tropics.)
   Queensland: Cooktown, Cairns, Townsville, Brisbane.
   Northern Territory: Darwin.
   New South Wales: Lismore.
   Western Australia: Perth.
   Victoria: Melbourne.
   Serious pest in North Australia.
9. *Pheidole oceanica* Mayr. (Samoa, Tonga.)
   Northern Territory: Darwin.
   Queensland: Mackay, Cairns.
   General pest in North Australia.
10. *Solenopsis geminata* var. *rufa* (Jerd.). (India.)
    Northern Territory: Darwin.
    North Western Australia: Broome.
    General pest in North Australia.
11. *Triglyphothrix striatidens* (Emery). (Burma, Ceylon.)
    Northern Territory: Darwin.
    Queensland: Mackay, Townsville.
    House and store pest.
12. *Tetramorium guineense* (Fabr.). (Cosmopolitan.)
    All States.
13. *Tetramorium simillimum* (Smith). (Cosmopolitan.)
    All States.
14. *Tetramorium pacificum* subsp. *subscabra* Emery. (Ceylon, India.)
    Northern Territory: Darwin, Batchelor.

DOLICHODERINAE.

15. *Iridomyrmex anceps* (Rogers). (India, Malaya.)
    Northern Territory: Darwin.
    Queensland: Cairns.
    Western Australia: Geraldton, Albany.
16. *Iridomyrmex anceps* var. *papuana* Emery. (New Guinea.)
    Northern Territory: Darwin.
    Queensland: Cooktown, Cairns.
    House pest.
17. *Iridomyrmex humilis* Mayr. (Argentine.)
    Victoria: Balwyn, Brunswick, Caulfield, Dandenong, Williamstown.

18. *Tapinoma (Micromyrma) melanocephalum* (Fabr.). (Cosmopolitan.)
    Northern Territory: Darwin, Point Charles.
    Queensland: Cooktown, Cairns, Townsville.
    Western Australia: Broome.
    Serious pest in houses.
19. *Technomyrmex albipes* (Smith). (Cosmopolitan.)
    All States.
    Serious house and store pest.

FORMICINAE.

20. *Anoplolepis (Anoplolepis) longipes* (Jerd). (Cosmopolitan in Tropics.)
    Northern Territory: Darwin.
    General pest.
21. *Paratrechina (Paratrechina) longicornis* (Latr.).
    Queensland: Cairns, Brisbane.
    Western Australia: Geraldton, Fremantle.
    General pest.
22. *Paratrechina (Nylanderia) vividula* (Nyl.). (Cosmopolitan.)
    New South Wales: Sydney.
    General pest.
23. *Lasius (Lasius) niger* (Linne). (Europe.)
    Tasmania: Known only by one doubtful record.
24. *Polyrhachis (Myrmhopla) bicolor* Smith. (India, Malaya.)
    Northern Territory: Darwin.
    Probably not a pest.

Forel has recorded the European ant *Lasius (Lasius) niger* Linn. from Tasmania. Although several large collections of ants from that State have been received and examined at the National Museum, this species has not been represented in any of them.

The following species are known to be carried in plants of Orchids and Cacti:—*Odontomachus haematoda* (Linne); *Phiedole megacephala* (Fabr.); *Iridomyrmex humilis* Mayr; *Technomyrmex albipes* (Smith); *Monomorium floricola* (Jerd.); *Monomorium pharaonis* (Linn.); *Paratrechina longicornis* (Latr.).

Several of our native ants give a certain amount of trouble during the summer months when they invade the house and attack foodstuffs. Most of them are small black ants (*Irido-*

myrmex) and have a nasty smell more or less like rancid butter. As a general rule the visits of these ants are short. The nests being small, they are not difficult to eradicate.

The only species causing serious inconvenience is the common "meat ant" (*Iridomyrmex detectus* Smith) when it establishes a nest near a dwelling. As well as being the type of the genus, it is the largest species, being three or four times larger than the ordinary black house-ant. The following articles have been written about this ant and its control:—

1. Clark, J. "Ants as Pests." Jour. Dept. Agric. W. Aust., i, pp. 317-319, 1924.
2. Froggatt, W. W. "Domestic Insects : Ants." Agric. Gaz., N.S. Wales, xvi, pp. 861-866, Sept. 1905. Reprinted as Miscellaneous publication No. 889, with catalogue of Australasian species, 1906.
3. Greaves, T. "The Control of Meat Ants." Jour. Council Sc. & Ind. Research, xii, (2), pp. 109-114, 1939.
4. Summerville, W. A. T. "The Control of Meat Ants." Queensland Agric. Jour., xxxi, pp. 111-113, 1929.

Mem. Nat. Mus. Vict., 12, 1941.

AUSTRALIAN FORMICIDAE.

Notes and New Species.

By John Clark,
Entomologist, National Museum of Victoria.

Plate XIII.

In this paper nineteen new species, representing four subfamilies are described and figured, and a new genus has been created to contain a number of the species.

Recent investigations in the genus *Phyracaces* revealed a well defined group of large species whose workers possess ocelli. As the workers in this genus are characterized as having no ocelli, a new genus *Neophyracaces* gen. nov. is erected to contain the species whose workers possess ocelli, as it is evident that they cannot be maintained in *Phyracaces*. The genotype selected is *Pyhracaces clarus* Clark, all phases of this species being known. At present fifteen species are included in the new genus, four of these are described herein. Both genera have a similar distribution, being found in each of the States except Tasmania. At present no species of *Cerapachyinae* is recorded from Tasmania. Several species of *Phyracaces* are found near the sea coast, but they are more common and abundant in the dry and warm inland area. All appear to be robber ants and most of the species have been found whilst they were raiding the nests of other ants. Some interesting observations on their habits have been contributed to this paper by Mr. H. Potter, a keen naturalist and observer in Northern Victoria. During the past few years Mr. Potter has made some interesting discoveries concerning the ants and their habits, and as a result of his labour several species are described herein.

It is interesting to note that the four species of robber ants discovered by Mr. Potter proved to be new species. One of these, *Neophyracaces potteri* sp. nov., confines its attention to a species of the genus *Iridomyrmex*; this species also is new, (*Iridomyrmex viridigaster* sp. nov.). The following notes on *N. potteri* have been supplied by Mr. Potter from observations made on his farm in Northern Victoria:—

"During the afternoon of January 21st, a nest of this species was discovered near the gate leading into the sheep yard. Unlike most nests this one was inconspicuous and indicated only by a small hole in the ground; there was no

trace of the earth which had been excavated from below, and apparently the soil had been scattered some distance from the nest. A few workers, each with its abdomen raised upwards, were moving rapidly about. At 3 p.m., with the shade temperature at 90° Fahr., a large number of the ants was seen leaving the nest and travelling to a series of nest holes about twenty-two yards away. The series of nests belong to a small dark coloured ant (*Iridomyrmex viridigaster*). On reaching these nests the robbers did not hesitate, they went boldly in and apparently got little resistance as they soon emerged again each carrying a larva or pupa of the *Iridomyrmex* with which they returned to their own nests. Little or no order was maintained during the raids, each ant seemed to work independently, but a constant stream kept on coming with nothing and returning with larva or pupa. Later, at 4 p.m., there was no sign of the robbers near the nests which they had been robbing; apparently the raid had ceased. One robber ant was seen carrying an apparently injured companion back to their nest. When this ant was stopped about one foot away from the nest the injured ant was dropped, although able to walk it could not keep up with the others. The injured one was picked up again by her companion and carried into the nest.

"At 5 p.m. when again observed, some of the *Iridomyrmex* were attacking the robbers. The method of attack was similar in all cases. Several of the *Iridomyrmex* seized the antennae of the robbers whilst others seized the legs. After a short struggle the victim was helpless—several dead robbers were seen near. The *Iridomyrmex* not engaged with the robber ants were removing their larvae and pupae, taking them away in another direction.

"23 Jan., '34. The robber ants were seen running about but did not appear to be carrying anything. They were emerging from two holes about three feet apart.

"14 Feb., '34. At 2.30 p.m. with the temperature at 90° Fahr. in the shade, a few ants were seen out foraging not far from the second entrance to their nest, no sign of any near the first entrance. Half an hour later all had disappeared.

"20 Feb., '34. At 4 p.m. two ants were hunting near the first entrance. One walked into a line of *Iridomyrmex* travelling along not far from the entrance to the robbers' nest. The *Iridomyrmex* immediately attacked the intruder seizing it by the antennae and legs. Other three robbers had received a similar fate further along the line. On returning to the place at 6.30 p.m. only one robber was seen, there was

no trace of the other three prisoners. The ant still held by the *Iridomyrmex* was alive and did not appear to be much damaged. One of the robbers appeared at the second entrance but went in again. There was no sign of life at the nests which had been attacked by the robbers.

"28 Feb., '34. Robber ants busy at both entrances, bringing out small bits of earth with which they formed a ring round each entrance. The particles are finer than those usually brought out by ants of their size. Some, on coming out, deposited what they carried and hurriedly went back, others went foraging around a few feet from the nest, while one remained near the entrance scraping the earth back with her feet. When foraging they run with the head down, close to the ground and the abdomen raised above the thorax. They move very rapidly.

"2 March, '34. At 3 p.m. a few ants were out foraging. One was carrying a piece of straw-like material. On being touched the ant dropped its load and disappeared into a crack in the ground, in a short time it reappeared and returned for its load which it carried to the nest. The robbers have made a third entrance to their nest, the new hole is about one foot from the first entrance. The ants were seen to emerge and return by the new entrance. At 7 p.m. all three entrances were closed."

Another of the ants discovered by Mr. Potter is a peculiar species which is placed in the genus *Melophorus* (*M. fulvihirtus* sp. nov.). Most of the known species of *Melophorus* are harvesting ants, collecting the seeds of grasses and small plants near the nest. The new species apparently does not collect seeds but appears to be a robber ant. Each occasion on which this ant has been seen, it was robbing the nests of the common "Meat Ant" (*Iridomyrmex detectus* Smith), probably the most pugnacious ant in Australia.

Mr. Potter has supplied the following notes regarding this robber ant:—

"In this district there is a colony of this ant in, or near every nest of the 'Meat Ant' (*Iridomyrmex detectus* Smith). Generally the nest is situated near the middle of the meat ant's nest but sometimes in the ground alongside the nest. I have not found them more than a few feet away. The entrance to the nest is funnel-shaped and is not surrounded by a mound; apparently very little earth is excavated from below. At night the entrance is closed with small stones and earth. During cold weather the ants are not active but a few of the large workers are to be seen just inside the entrance

as though on guard. When the nest is disturbed the large workers come out to investigate but do not show fight.

"The raiding is done by the small workers. They run very fast and seem to work more or less singly, never in a body as is usual with robber ants. Frequently when leaving or returning to the nest they run about as though not sure of their direction. They work only during the hottest part of the day when the temperature rises above 90° Fahr. At this time the meat ant does not leave its nest. The large workers do not take part in the raids but remain at their own nest and, generally, are busily clearing the entrance. During the raids, which are continued for half an hour, workers of *I. detectus* are not to be seen.

"On one occasion while watching a raid I stamped on the meat ants' nest to see if they would attack the raiders. The meat ants rushed out and came in my direction but took no notice of the raiding ants."

In addition to the observations given above, notes are being compiled by Mr. Potter on other species of robber ants and some of the harvesting ants found in his district. They are of particular interest as the only ants known from that area are those collected by Mr. Potter.

Family **FORMICIDAE** Latreille.

Subfamily **Cerapachyinae** Forel.
Ann. Soc. Ent. Belg., xxxvii, p. 162, 1893.

Genus PHYRACACES Emery.
Rend. Accad. Sc. Inst., Bologna, p. 23, 1901-02.

Phyracaces crassus sp. nov.
Plate XIII, Fig. 1.

Worker. Length 7·5-8 mm.

Dark castaneous throughout, eyes and margins of thorax and node black. Shining. Mandibles coarsely and deeply punctate. Clypeus smooth. Head finely reticulate-rugose in front of eyes, smooth behind with large scattered punctures. Thorax, node and gaster with numerous scattered large shallow piligerous punctures.

Hair reddish, long and erect on head and body, shorter and suberect on antennae and legs. Pubescence grey, apparent only on funiculi.

Head as long as broad, broadest behind, occipital border feebly convex, sides more strongly convex, posterior angles sharp, a strong ridge extends along occipital border and is continued on the sides of the head to a point midway between the eyes and occipital border. Mandibles large and triangular, edentate, cutting edge sharp. Clypeus very short. Frontal carinae erect, narrowing behind, truncate then confluent to level with middle of eyes.

Carinae of cheeks strong, extending back level with the posterior margins of eyes. Eyes large and convex, placed at middle of sides. Scapes extend very slightly beyond posterior margins of eyes; second and third segments of funiculus equal in length, one-sixth longer than first, apical as long as the two preceding combined. Thorax one and one-half times longer than broad, as broad through epinotum as through pronotum, without traces of sutures. Pronotum broadly convex in front, strongly convex on sides, anterior angles sharp, the three borders strongly margined, mesonotal region strongly constricted, one-fourth narrower than pronotum, sides not margined. Epinotum strongly convex on sides, posterior border straight with a small sharp indention in the middle, the angles sharp, the three borders strongly margined; in profile strongly convex longitudinally, without traces of sutures, declivity feebly convex, sides margined. Node one-third broader than long, broadest at the middle, anterior border straight, sides strongly convex, the three borders strongly margined, anterior angles sharp, posterior angles produced backward as broad sharp spines as long as broad at base; in profile as long as high, anterior face vertical, slightly concave, superior edge sharp, dorsum convex, rounded into the convex posterior face, dorsal margin straight to posterior fourth ending in a broad sharp spine directed backward and upward, almost twice as long as broad at base. Postpetiole one-fifth broader than long, broadest at middle, anterior border concave, submarginate, sides strongly convex, anterior half feebly margined, constriction deep and wide. First segment of gaster one-third broader than long, strongly convex on sides. Legs long and slender, posterior coxae with a broad translucent laminae.

Male and female unknown.

Habitat.—Victoria: Hattah (J. Clark, Sept. 1939).

The node of this species is similar to that of *P. grandis* Clark, from South Australia. The size, colour and other features are quite different. No nest of the species was seen; several workers were found foraging in the Mallee scrub.

Phyracaces dromus sp. nov.

Plate XIII, Figs. 2, 3.

Worker. Length 4·2 mm.

Ferruginous; head, antennae and legs lighter, more yellowish, eyes and margins of thorax and node black.

Shining, microscopically reticulate throughout, numerous fine shallow piligerous punctures.

Hair yellow, erect, long and abundant, particularly on gaster, short and suberect on antennae and legs.

Head very slightly longer than broad, sides and occipital border convex, angles rounded. Mandibles short and broad, furnished with numerous short sharp teeth. Frontal carinae erect and parallel truncate behind, carinae of cheeks prominent, extending to anterior edge of eyes with a short branch extending inward near the apex. Eyes large, flatly convex, placed at middle of sides. Scapes extend to middle of eyes; first segment of funiculus as long as the second and third combined, second to ninth broader than long, apical bluntly pointed, as long as the three preceding combined. Thorax twice as long as broad, without traces of sutures, sides and posterior border sharply margined, anterior border feebly margined, angles blunt, posterior angles sharp; in profile convex longitudinally, a strong sharp ridge extends from the anterior superior angle down to the anterior inferior angle, epinotal declivity

straight, at an obtuse angle, sides sharply margined. Node one-fifth broader than long, broadest at middle, sides convex, strongly margined, anterior border concave, sharply produced, posterior angles produced backwards as short broad spines as long as broad at base; in profile anterior face convex, high, superior angle sharp, dorsum convex the margin almost straight, the angle behind produced upward and backward as a thin sharp spine. Postpetiole one-third broader than long, broadest behind, sides and front almost straight, feebly convex, angles rounded; constriction deep and wide. First segment of gaster one-fourth broader than long, sides strongly convex. Legs long and robust.

Female. Length 5·2 mm. (Ergatoid).

Larger and more robust than the worker. Colour, sculpture and pilosity similar. Ocelli prominent. Thoracic segments indicated but weakly developed, mesonotum and scutellum small. Node broader, one-third broader than long. Legs more robust.

Habitat.—Victoria: Patho (H. A. Potter).

A small colony was found whilst they were raiding the nest of a small black ant.

Genus NEOPHYRACACES gen. nov.

Worker. Antennae with twelve segments, apical segment large, as long as or longer than the two preceding combined. Eyes and ocelli large. Thorax and node strongly margined.

Female. Similar to the worker; winged or ergatoid.

Male. Similar to the male of *Phyracaces.*

Genotype *Phyracaces clarus* Clark.

Separated from *Phyracaces* by the workers possessing ocelli.

Neophyracaces potteri sp. nov.

Plate XIII, Figs. 4, 5.

Worker. Length 7-7·5 mm.

Bright reddish yellow throughout; the eyes, margins of the thorax and node black.

Smooth and shining, with scattered shallow piligerous punctures. Front of head and apical margins of segments of gaster microscopically reticulate.

Hair yellow, long, erect and abundant throughout, shorter and suberect on antennae and legs. Pubescence confined to apical segments of antennae, very fine, short and adpressed.

Head as long as broad, sides strongly convex, posterior angles broadly rounded, occipital border short and straight. Mandibles with numerous small fine teeth. Clypeus very short. Frontal carinae short and erect, parallel in front, truncate and converging behind, twice as long as broad. Carinae of cheeks prominent extending backward level with anterior margin of eyes. Eyes rather flatly convex, placed at the middle of sides. Ocelli large and prominent. Scapes extend backward to posterior margin of eyes; first segment of funiculus as long as broad, second to eleventh broader than long, apical pointed, as long as the three preceding combined. Thorax one and three-fourths times longer than broad, as broad behind as in front, strongly constricted at the mesonotal region, sutures feebly defined; pronotum much broader than long, sides and front strongly convex, the sides sharply margined,

epinotum twice as broad as long, sides convex, posterior border straight, sharply margined; in profile convex longitudinally, without traces of sutures, pronotum rounded downward in front, epinotal declivity at an obtuse angle, slightly longer than dorsum of epinotum from which it is divided by a sharp ridge. Node as broad as long, slightly broader behind than in front, dorsum and sides convex, sharply margined, anterior border concave, not margined, posterior border straight not margined, the angles produced backward as broad flat spines, bluntly pointed, as long as broad at base, the inner edge straight, the outer edge curved inward; in profile one-fourth longer than high, dome-shaped, anterior face convex, sharply margined by a continuation of the dorsal edge, sharp margin of dorsum feebly convex, slightly higher behind than in front, produced backward and upward as a long sharp spine, twice as long as broad at base; a short sharp spine on ventral surface in front, directed backwards. Postpetiole barely one-third broader than long, broader behind than in front, sides convex, anterior border straight, angles broadly rounded, dorsum evenly convex in all directions; constriction between postpetiole and gaster wide but not deep. First segment of gaster one-third broader than long, broader behind than in front, sides strongly convex. Pygidium truncate, concave, margined on sides by a sharp ridge, the ridge furnished with numerous short sharp translucent spines. Sting long and stout. Legs long and robust.

Male. Length 7.5-8 mm.

Colour, sculpture and pilosity as on the worker.

Head one-seventh broader than long, almost circular. Mandibles large, triangular, furnished with numerous fine small sharp teeth. Clypeus short, broadly rounded in front. Frontal carinae large and erect, truncate and confluent behind. Eyes placed at middle, occupying one-third of sides. Ocelli large and prominent. Scapes extend backward almost level with posterior margin of eyes; all funicular segments longer than broad. Thorax barely twice as long as broad. Pronotum short, hemispherical, a short broad tubercle-like projection on top at pro-mesonotal suture. Mesonotum one-sixth longer than broad, bluntly rounded in front. Mayrian and parapsidal furrows feebly impressed. Scutellum one-third broader than long, oval. Epinotum twice as broad as long, convex both ways, posterior border sharply margined; in profile vertical, high, convex, sharp pointed and projecting in front above. Mesonotum evenly convex from apex to base. Scutellum dome-shaped, twice as long as high. Epinotum convex longitudinally, one-third longer than declivity. Declivity at an obtuse angle, straight, boundary between declivity and dorsum marked by a strong ridge. Node one-fourth broader than long, very slightly broader behind than in front, anterior border straight sharply margined, angles sharp, sides and posterior border convex, sides submarginate in front to middle; in profile as high as long, dome-shaped, a broad blunt tooth-like projection directed backward in front below. Postpetiole barely one-third broader than long, sides and front strongly convex; constriction between postpetiole and gaster wide but not deep. First segment of gaster almost one-third broader than long, much broader behind than in front, sides strongly convex. Genitalia retracted. Legs long and slender.

Habitat.—Victoria: Patho (H. A. Potter).

Neophyracaces gwynethae sp. nov.

Plate XIII, Figs. 6, 7.

Worker. Length 8·5 mm.

Bright ferruginous. Eyes, ocelli, margins of thorax, node and postpetiole dark brown.

Smooth and shining; very finely and densely reticulate; mandibles with a few large shallow punctures, obsolete near base; head, thorax and gaster with small scattered piligerous punctures, very sparse throughout.

Hair yellow, long and erect and abundant on apical segments of gaster, shorter and sparse elsewhere, strong and bristle-like on scapes, very short and adpressed on funiculi and legs. Pubescence nil.

Head as long as broad, sides convex, occipital border short, straight or very feebly convex, angles rounded. Mandibles edentate, edges sharp. Clypeus very short, vertical. Frontal carinae erect, converging slightly, and truncate behind, one-third longer than broad in front. Carinae of cheeks short, prominent in front, obsolete behind, hardly extending beyond frontal carinae behind. Eyes large and convex, placed at middle of sides. Ocelli large and prominent. Scapes extend beyond posterior margin of eyes by barely their thickness; first to fourth segments of funiculus as long as broad, fifth to seventh very slightly broader than long, eighth to tenth as long as broad, apical pointed, as long as the two preceding combined. Thorax barely twice as long as broad, very strongly constricted at mesonotal region. Pronotum almost one-third broader than long, sides and front convex and sharply margined, margins stop abruptly at pro-mesonotal suture. Mesonotum as long as broad, sutures feebly indicated, sides not margined. Epinotum one-third broader than long, sides convex, strongly margined, posterior straight, margined, angles sharp; in profile dorsum convex longitudinally, anterior border of pronotum short and truncate, epinotal declivity at an obtuse angle, half as long as dorsum from which it is separated by a sharp ridge, sides not margined. Node slightly broader than long, one-fifth broader behind than in front, sides convex and sharply margined, anterior border concave, the angles sharply produced in front, posterior angles produced backward and slightly inward at points, as long as broad at base; in profile one-fifth longer than high, anterior face vertical, sharply margined, dorsum feebly convex, anterior edge sharp, not produced, posterior greatly produced backward, sharply pointed, twice as long as broad at base. Postpetiole one-third broader than long, much broader behind than in front, sides convex, anterior border straight, sharply margined, the angles sharp, the margins extend along the anterior third of sides. First segment of gaster one-third broader than long, broader behind than in front, sides convex. Legs long and robust.

Male. Length 7·2 mm.

Colour lighter than in worker, back of head and a large Y shaped patch on mesonotum yellow. Wings translucent, veins brown.

Sculpture and pilosity as in the worker.

Head fully one-fourth broader than long, broadly arched from the eyes behind. Mandibles large, feebly dentate. Frontal carinae erect, parallel, diverging slightly outward behind limiting the antennal fovea. Eyes very large occupying almost all the sides. Ocelli large and convex. Scapes extend back level with the middle of the eyes; second segment of funiculus twice as long as first, remainder longer than broad, apical sharp pointed, longer than the two preceding combined. Thorax almost twice as long as broad. Pronotum hardly seen from above, strongly convex in all directions. Mesonotum very slightly broader than long, parapsidal furrows strongly impressed, mayrian furrows feebly impressed. Scutellum one and one-half times broader than long, oval. Epinotum almost twice as broad as long, posterior border straight; in profile pronotum vertical, mesonotum strongly convex in front, feebly convex at middle, scutellum twice as long as high, convex, epinotum straight, highest in front, declivity feebly concave, slightly shorter than dorsum from

which it is separated by a sharp ridge. Node one and three-quarters times broader than long, oval; in profile almost twice as long as high, hemispherical. Postpetiole one-fifth broader than long, broadest behind, sides convex, anterior edge straight, angles rounded; constriction between postpetiole and first segment of gaster deep and wide. First segment of gaster one-third broader than long, broadest behind, sides strongly convex. Genitalia retracted; legs long and slender.

Habitat.—Victoria: Red Cliffs (Miss G. Claringbull).

In size and colour somewhat similar to *N. potteri* but separated by the shape of the head and nodes.

Neophyracaces macrops sp. nov.
Plate XIII, Fig. 8.

Worker. Length 6 mm.

Bright ferruginous throughout; eyes, ocelli and margins of thorax and node black.

Smooth and shining, microscopically reticulate throughout, with numerous shallow scattered piligerous punctures.

Hair yellow, erect, long and rather abundant, shorter on antennae and legs.

Head one-ninth longer than broad, almost as broad in front as behind, sides and occipital border feebly convex, angles rounded. Mandibles large, furnished with numerous very small sharp teeth. Frontal carinae erect, converging gradually behind, one-third longer than broad in front. Carinae of cheeks short and sharp, extend backward level with frontal carinae. Eyes large, rather flatly convex, placed at middle of sides. Ocelli large and convex. Scapes short, not extending to the posterior margin of eyes by fully their thickness; first segment of funiculus longer than broad, second to eighth broader than long, apical bluntly pointed, longer than the two preceding combined. Thorax twice as long as broad, feebly constricted at mesonotal region, pro-mesonotal and meso-epinotal sutures indistinct. Pronotum one-fourth broader than long, sides and front convex, angles bluntly rounded. Mesonotum one-third broader than long, sides straight. Epinotum one-third broader than long, sides strongly convex, posterior border straight or feebly convex, angles sharp, all edges of thorax sharply margined; in profile evenly convex from apex to base, pronotum truncate in front, epinotal declivity feebly concave, sides margined, separated from dorsum by a sharp ridge. Node one-fifth broader than long, sides convex, sharply margined, anterior border concave, angles sharp, posterior border convex, the angles produced backward and curved inward as broad flat spines half as long as broad at base; in profile anterior face straight, sharply margined on sides, superior angle sharp, dorsum convex, highest behind middle, margin sharp, ending behind in a slender spine directed backward and slightly upward. Postpetiole one-fifth broader than long, broadest behind, sides and front feebly convex, angles bluntly rounded; constriction between postpetiole and first segment of gaster deep and wide. First segment of gaster one-third broader than long, strongly convex. Legs long and robust.

Habitat.—Victoria: Patho (H. A. Potter).

A small colony was found whilst they were robbing a nest of *Iridomyrmex rufoniger* Lowne.

Neophyracaces piliventris sp. nov.
Plate XIII, Fig. 9.

Worker. Length 8-8·5 mm.

Yellowish-red, margins of thorax and node black.

Shining. Mandibles with some large shallow punctures. Head, thorax, node and gaster very finely and densely reticulate, with large shallow piligerous punctures, more abundant on gaster.

Hair yellow, long and erect, particularly abundant on gaster, shorter and suberect on antennae and legs. Pubescence whitish, apparent only on antennae and legs.

Head as long as broad across the eyes, occipital border evenly arched from eye to eye, sides in front of eyes straight. Mandibles large, edentate. Frontal carinae erect, high, parallel, truncate behind, twice as long as broad. Carinae of cheeks prominent, front angles sharp and raised. Scapes extend beyond hind margin of eyes by half their thickness; first to tenth segments of funiculus slightly broader than long, apical pointed, twice as long as broad and as long as the two preceding combined. Eyes large and convex, their centre slightly behind the middle of the sides. Ocelli large and prominent. Thorax one and three-quarters times longer than broad, slightly broader at epinotum than pronotum, sutures distinct, strongly constricted at mesonotal region. Pronotum twice as broad as long, front and sides strongly convex, sides margined. The margins continued and almost meeting in front. Mesonotum one-fourth broader than long, convex in front and behind, concave on sides, not margined, one-fifth narrower than pronotum. Epinotum twice as broad as long, sides strongly convex and margined, posterior border straight or feebly convex, margined, angles sharp; in profile evenly convex longitudinally, sutures indicated but feebly impressed, declivity concave, sides margined. Node one-fifth broader than long, broadest behind, sides convex to anterior fourth, sharply margined, anterior edges convex, not margined, angles sharp, posterior angles produced as long sharp translucent spines twice as long as broad at base, curved slightly inward; in profile anterior face short and straight, broadly rounded into dorsum, margined on sides, dorsum convex, highest in front, posterior angles produced backwards as broad sharp spines as long as broad at base, declivity short, rounded into dorsum. Postpetiole almost one-third broader than long, broadest behind, sides strongly convex, anterior edge straight, margined, the angles sharp, constriction between postpetiole and gaster deep and wide. First segment of gaster one-sixth broader than long, sides convex. Legs long and slender.

Male and female unknown.

Habitat.—Queensland: Brisbane (H. Hacker).

Subfamily **Ponerinae** Lepeletier.
Hist. Nat. Ins. Hymn., i, p. 185, 1836.

Genus RHYTIDOPONERA Mayr.
Verh. Zool. bot. Ges., Wien, xii, p. 731, 1862.

Since the revision of this genus, these Memoirs, viii, 1936, the following species have been received:—

Rhytidoponera barretti sp. nov.
Plate XIII, Fig. 10.

Worker. Length 10·5-11 mm.

Black; mandibles, apical half of funiculus and all the tarsi reddish brown.

Mandibles strongly and evenly striate longitudinally. Head longitudinally striate-rugose, the rugae diverging strongly outward behind. Clypeus longitudinally striate. Scapes very finely striate longitudinally. Pronotum and mesonotum coarsely and irregularly rugose, spaces between rugae shining. Epinotum coarsely rugose transversely, some very fine transverse striae in front. Node more irregularly but finely rugose. Postpetiole finely and densely striate, the striae longitudinally arched. First segment of gaster finely and densely striate longitudinally, remainder of segments densely reticulate.

Hair yellow, short and erect, abundant throughout, very short and suberect on scapes and legs. Pubescence yellow, apparent only on funiculus.

Head one-sixth longer than broad, sides straight, almost parallel, occipital border very feebly concave, the angles broadly rounded. Mandibles broad, furnished with numerous very small sharp teeth. Clypeus convex in all directions. Frontal area small, triangular. Frontal carinae as long as broad in front. Scapes extend beyond occipital border by fully one-third of their length; second segment of funiculus one-third longer than first, third slightly shorter than second, remainder subequal, apical one-third longer than the preceding. Eyes small, globular, placed behind the middle of sides. Thorax one and three-quarters times longer than broad. Pronotum fully one-third broader than long, slightly compressed on sides, convex in front and above; pro-mesonotal suture sharply impressed. Mesonotum one-fourth broader than long, convex in all directions, meso-epinotal suture indistinct. Epinotum as long as broad; in profile pronotum raised at an obtuse angle, flattened to basal fourth, then convex to base, there is a deep impression on sides, suture sharply defined. Mesonotum convex. Meso-epinotal suture indicated but not impressed. Epinotum evenly convex from base to foot of declivity. Node twice as broad as long, oval, convex transversely; in profile twice as high as long, anterior and posterior faces straight and parallel, dorsum convex, ventral spine twice as long as broad at base, abruptly reduced and pointed in front. Postpetiole almost one-third broader than long, sides and front strongly convex; constriction deep and sharp. First segment of gaster one-seventh broader than long, broadest in front, sides convex. Legs long and robust.

Habitat.—Central Australia: Harts Range (C. L. Barrett, July 1938).

Near *R. maniae* Forel but larger and more robust.

Rhytidoponera greavesi sp. nov.
Plate XIII, Fig. 11.

Worker. Length 11-12 mm.

Bright ferriginous throughout. Mandibles and legs lighter.

Mandibles very finely, superficially striate longitudinally with numerous large shallow punctures. Clypeus coarsely striate longitudinally. Head coarsely striate, transverse on the posterior third, longitudinal between frontal carinae then circling round the antennal fovea. Scapes very finely and densely striate longitudinally. Thorax transversely and coarsely striate. Node circularly striate. Legs smooth and shining, finely punctate, anterior coxae transversely striate.

Hair yellow, short and erect, abundant throughout not shorter on antennae and legs. No pubescence.

Head one-seventh longer than broad, broader in front than behind, sides convex, occipital border convex with a slight depression in the middle, angles sharp, projecting slightly laterally, a small sharp crest extends from angle to angle in front. Mandibles very finely denticulate. Clypeus convex above and in front. Frontal area large. Frontal carinae as long as broad in front. Scapes extend beyond occipital border by fully one-third their length; first and third segments of funiculus equal in length, one-seventh shorter than second, apical as long as the two preceding combined. Eyes globular placed behind the middle of the sides. Thorax twice as long as broad, pro-mesonotal suture sharply impressed, meso-epinotal suture feebly indicated. Pronotum twice as broad as long, convex in all directions, sides slightly compressed. Mesonotum one-fifth broader than long, broadest in front, convex. Epinotum as long as broad, convex laterally; in profile pronotum raised gradually convex to basal fourth then abruptly convex to base, a deep indention in middle of sides. Mesonotum evenly convex, as long as dorsum of epinotum but higher. Epinotum straight, curved into the short declivity behind. Node barely twice as broad as long, oval, dorsum convex transversely; in profile twice as high as long, anterior and posterior faces parallel, dorsum convex, the ventral spine long, slender and sharp. Postpetiole barely one-third broader than long, strongly convex in front, constriction deep and wide. First segment of gaster slightly broader than long, broadest in front, convex. Legs long and robust.

Male. Unknown.

Habitat.—North Queensland: Julia Creek (T. Greaves).

Near *R. socrus* Forel, from which it is distinguished by the colour, shape and sculpture of thorax and node.

Rhytidoponera rufithorax sp. nov.
Plate XIII, Fig. 12.

Worker. Length 7·5-8·5 mm.

Mandibles, head, thorax and node red, gaster black, scapes and legs brown, funiculi and tarsi yellowish brown.

Mandibles and scapes very finely and densely striate longitudinally. Head coarsely punctate-rugose, the rugae fine, punctures broad and shallow, shining at the bottom, spaces between finely reticulate. Thorax very finely and densely reticulate, with widely spaced, large, shallow punctures shining at the bottom. Epinotal declivity more transversely rugose. Node more finely punctate-rugose. Postpetiole very finely densely striate transversely arched. First segment of gaster more finely striate transversely. Legs very finely striate transversely, the striae in some examples obsolete.

Hair yellow, short and erect, sparse throughout, more abundant but shorter and finer on antennae and legs. Pubescence whitish, confined to funiculi.

Head fully one-fifth longer than broad, sides feebly convex, occipital border convex, with a short concave depression in the middle, angles rounded, a sharp crest limits the border and angles. Mandibles edentate, cutting edge sharp. Clypeus convex in all directions. Frontal area large, triangular. Frontal carinae as long as broad in front. Scapes extend beyond occipital border by more than one-third of their length; first four segments of

funiculus equal in length, apical as long as the two preceding combined. Eyes globular, placed behind the middle of sides. Thorax twice as long as broad, pro-mesonotal suture sharply impressed, meso-epinotal suture indicated. Pronotum one-fourth broader than long, convex in all directions, a slight depression on sides. Mesonotum one-fourth broader than long, convex in all directions. Epinotum barely as long as broad, convex laterally; in profile pronotum raised and convex from apex to base, pro-mesonotal suture deep and sharp. Mesonotum flatly convex, meso-epinotal suture faintly impressed. Epinotum feebly convex, almost straight from base to front of declivity. Node barely twice as broad as long, oval, convex transversely; in profile twice as high as long, anterior and posterior faces vertical, parallel, dorsum flatly convex, edges sharply rounded; ventral spine short, slender and sharp. Postpetiole almost one-fourth broader than long, cone-shaped in front, constriction wide but shallow. First segment of gaster almost as long as broad, broadest in front. Legs long, rather slender.

Habitat.—Northern Territory: Alexandria station (T. Greaves).

Genus CHALCOPONERA Emery.

Ann. Mus. Stor. Nat., Genova, xxxviii, p. 548, 1897.

Chalcoponera viridis sp. nov.

Plate XIII, Fig. 13.

Worker. Length 6·5-7 mm.

Head, thorax and gaster bright metallic green; mandibles, antennae and legs brown.

Mandibles very finely striate-rugose longitudinally. Head longitudinally rugose on the middle, irregularly punctate-rugose on sides and behind. Scapes finely and densely striate-reticulate. Thorax and node coarsely punctate-rugose, the punctures large and deep, finely and densely reticulate at the bottom. Postpetiole transversely arched striate and with numerous large shallow punctures, more abundant in front than behind. First segment of gaster very finely and densely striate-reticulate circularly, almost transverse in front. Legs finely reticulate.

Hair yellow, long and erect, abundant throughout, shorter and suberect on antennae and legs. Pubescence apparent only on antennae.

Head very slightly longer than broad, sides convex, occipital border concave, angles rounded. Mandibles furnished with numerous small sharp teeth. Clypeus convex above, produced and straight or feebly concave in front. Frontal area small, triangular. Frontal carinae as long as broad behind. Scapes extend beyond occipital border by twice their thickness; first and second segments of funiculus equal length, one-fifth longer than third, apical as long as the two preceding combined. Eyes large, globular, placed behind the middle of sides. Thorax one-third longer than broad, pro-mesonotal suture sharply defined, meso-epinotal suture faintly indicated. Pronotum twice as broad as long, sides and front strongly convex, concave behind, dorsum flatly convex. Mesonotum fully one-fourth broader than long, convex in all directions. Epinotum as long as broad, convex laterally; in profile pronotum raised abruptly, convex, dorsum of pronotum, mesonotum and epinotum evenly convex to foot of declivity, sutures feebly impressed.

Node one-third broader than long, twice as broad behind as in front, sides convex, angles rounded, posterior face straight; in profile much higher than long, anterior and posterior faces straight and parallel, dorsum convex, dorsum slightly longer than posterior face, ventral spine very long and slender, almost four times longer than broad at base. Postpetiole two-fifths broader than long, strongly convex in front, sides straight, constriction deep and wide. First segment of gaster one-seventh broader than long, convex behind. Legs long and slender.

Male and female unknown.

Habitat.—South Australia: Kalmurina, Lake Eyre (Prof. J. W. Gregory 17.8.03).

Distinguished from all the other species by the colour, shape of thorax, node and the very long ventral spine.

Chalcoponera flavipes sp. nov.

Plate XIII, Fig. 14.

Worker. Length 4·5-5 mm.

Head, thorax, node and first two segments of gaster green. Mandibles, clypeus, antennae and legs reddish yellow, apex of gaster brownish.

Mandibles superficially striate-reticulate in the middle almost smooth near the edges. Clypeus longitudinally, head irregularly punctate-rugose, the punctures deep and densely and finely punctate-reticulate at the bottom. Scapes finely reticulate. Thorax and node coarsely punctate-rugose, more coarsely than on head, punctures wider and deeper, similarly reticulate at the bottom. Postpetiole very delicately striate transversely, with some shallow obsolete punctures. First segment of gaster even more delicately striate transversely. Legs shining.

Hair yellow, short and erect on head, thorax and node, longer on clypeus and gaster, short and suberect on antennae and legs. Pubescence nil.

Head barely one-seventh longer than broad, sides convex, occipital border straight or feebly convex, with a small but distinct crest in front, angles rounded. Mandibles furnished with three or four small sharp teeth on apical half, finely denticulate behind. Clypeus broadly convex above and in front. Frontal area small. Frontal carinae as long as broad in front. Scapes extend beyond occipital border by twice their thickness; first segment of funiculus one-fifth longer than second, apical twice as long as the two preceding combined. Eyes globular, placed behind the middle sides. Thorax fully one-third broader than long, pro-mesonotal suture sharply impressed, meso-epinotal suture faintly indicated. Pronotum one and three-quarters times broader than long, front and sides strongly convex, dorsum convex all ways. Mesonotum one and three-fifths times broader than long, convex in all directions. Epinotum almost twice as broad as long, convex laterally; in profile pronotum raised high and convex from apex to base, mesonotum flatly convex, dorsum of epinotum short and straight, one-fifth shorter than declivity face, declivity straight sloping at an obtuse angle. Node one-third broader than long, front and sides strongly convex, weakly convex behind, dorsum convex laterally; in profile one-third higher than long, one-fifth longer below than on top, anterior face straight sloping backward, posterior face vertical, dorsum feebly convex, as long as posterior face, ventral spine short, sharp and curved backward, placed at the anterior edge of a broad

plate-like process with a transparent puncture behind. Postpetiole one-sixth broader than long, sides and front convex. First segment of gaster very slightly broader than long, sides convex. Legs long and slender.

Male and female unknown.

Habitat.—South Australia: Ooldea (J. A. Kershaw, July 1921).

The colour and shape of the thorax separate this from all other known forms.

Chalcoponera hilli sp. nov.
Plate XIII, Fig. 15.

Worker. Length 5·5-6 mm.

Head, thorax, node and gaster brown, mandibles, antennae and legs reddish brown.

Mandibles finely striate longitudinally. Clypeus longitudinally rugose, with some shallow scattered punctures. Head longitudinally punctate-rugose, the rugae diverging outward behind. Scapes finely and densely striate longitudinally. Pronotum and mesonotum coarsely punctate-rugose, the punctures large and deep, shining at the bottom. Epinotum transversely rugose, the punctures small. Node irregularly punctate-rugose, almost as on epinotum. Postpetiole strongly striate transversely, the striate arched at posterior fourth, with some scattered obsolete punctures. First segment of gaster more finely and densely striate transversely.

Hair yellow, long and erect, abundant throughout, shorter and suberect on antennae and legs. No pubescence.

Head one-fifth longer than broad, sides convex, occipital border straight, angles sharply rounded, a feeble crest extends along the border. Mandibles large and broad, furnished with numerous small sharp teeth. Clypeus broadly convex above and in front. Frontal area large and triangular. Frontal carinae as long as broad in front. Scapes extend beyond occipital border by barely twice their thickness; first to tenth segments of funiculus equal in length, gradually increasing in thickness, apical as long as the two preceding combined. Eyes small, globular, placed at middle of sides. Thorax one and one-half times longer than broad, pro-mesonotal suture sharply impressed, meso-epinotal suture feebly indicated. Pronotum fully one-third broader than long, sides and front convex, very feebly convex transversely. Mesonotum three-fifths broader than long, convex in all directions. Epinotum almost twice as broad as long, strongly convex transversely; in profile pronotum raised abruptly, strongly convex to base. Mesonotum flatly convex, both sutures distinct. Epinotum one-third longer than declivity, feebly convex, declivity straight rounded into dorsum. Node almost one-third broader than long, sides and front strongly convex, feebly convex behind; in profile higher than long, anterior and posterior faces vertical, straight and parallel, dorsum slightly longer than posterior face, feebly convex, angles sharply rounded. Ventral process large and plate-like, one-third longer than broad, with a large transparent puncture in centre and a long sharp spine in front directed backward. Postpetiole one-third broader than long, strongly convex in front, weakly convex on sides, constriction deep and wide. First segment of gaster as long as broad, strong convex behind. Legs robust.

Male and female unknown.

Habitat.—North Queensland: Palm Island (G. F. Hill).

Chalcoponera pulchra sp. nov.

Plate XIII, Fig. 16.

Worker. Length 4·5-5·5 mm.

Head bright metallic violet, thorax and node bright metallic coppery violet, postpetiole and gaster bright metallic bluish violet. Mandibles, funiculi and tarsi reddish brown, scapes and legs blackish brown.

Mandibles very finely striate longitudinally, with large shallow punctures on disc. Clypeus longitudinally rugose. Head longitudinally punctate-rugose, the rugae diverging outward behind. Scapes finely striate longitudinally. Pronotum and mesonotum coarsely punctate-rugose, the punctures large and shallow, shining at the bottom; epinotum more transversely punctate-rugose. Postpetiole finely and densely striate, transversely arched, with some scattered obsolete punctures. First segment of gaster more delicately striate transversely.

Hair yellow, long and erect but not abundant, shorter, finer and suberect on antennae and legs. Pubescence nil.

Head a fraction longer than broad, sides convex, occipital border straight, crest sharp, slightly raised, angles sharply rounded. Mandibles furnished with large sharp teeth. Clypeus broadly convex above and in front. Frontal area small, triangular. Frontal carinae almost twice as long as broad in front, parallel, raised; head slightly depressed on outer sides of carinae. Scapes extend beyond occipital border by barely their thickness; first segment of funiculus one-third longer than second, remainder gradually increasing in thickness, apical as long as the two preceding combined. Eyes small and globular, placed at middle of sides. Thorax one and one-third times longer than broad, pro-mesonotal suture sharply impressed, meso-epinotal suture faintly indicated. Pronotum almost twice as broad as long, sides and front strongly convex, dorsum flatly convex. Mesonotum one-third broader than long, oval, convex transversely. Epinotum one-fourth broader than long, convex transversely; in profile strongly and evenly convex from apex of pronotum to apex of epinotal declivity, pro-mesonotal suture sharply impressed, meso-epinotal suture indicated. Node one and one-half times broader than long, broadest behind, convex in front, straight behind; in profile higher than long, anterior face vertical, convex and rounded into dorsum, posterior face vertical and straight, shorter than dorsum, top edge steep, ventral process one-third longer than broad, with a shallow puncture near the anterior edge, a long sharp spine in front directed very slightly forward. Postpetiole almost one-third broader than long, convex in front and on sides, constriction deep and wide. First segment of gaster slightly broader than long, convex behind. Legs slender.

Male and female unknown.

Habitat.—Western Australia: Forrest (C. L. Barrett, April, 1930).

The colour, shape of the thorax and node separate this from all the known species.

Chalcoponera brunnea sp. nov.

Plate XIII, Fig. 17.

Worker. Length 4-4·5 mm.

Head, thorax and node chocolate brown, gaster darker, mandibles yellow. Mandibles very finely striate longitudinally. Clypeus coarsely rugose

longitudinally. Head longitudinally rugose in front, diverging outward and more punctate-rugose behind. Scapes very finely and densely striate longitudinally. Thorax coarsely and irregularly punctate-rugose, the punctures large and deep, shining at the bottom. Node more finely punctate. Postpetiole very finely and densely reticulate-striate, the indistinct striae transversely arched. First segment of gaster very finely and densely striate transversely, the striate almost obsolete behind.

Hair yellow, short and erect throughout, shorter and suberect on antennae and legs. Pubescence nil.

Head very slightly longer than broad, sides convex, occipital border concave, with traces of a crest, angles sharply rounded. Mandibles furnished with small sharp teeth. Clypeus broadly convex above and in front. Frontal area large, triangular. Frontal carinae almost one-third longer than broad in front. Scapes extend beyond occipital border by their thickness; first segment of funiculus almost twice as long as second, apical as long as the two preceding combined. Eyes small, globular, their anterior border placed at middle of sides. Thorax almost one-third longer than broad, pro-mesonotal suture faintly impressed, meso-epinotal suture not indicated. Pronotum one and three-fifths broader than long, sides and front strongly convex, dorsum convex transversely. Mesonotum one-third broader than long, convex in all directions. Epinotum almost twice as broad as long, convex transversely; in profile pronotum abruptly raised convex, then evenly convex to top of epinotal declivity; dorsum of epinotum as long as declivity into which it is rounded. Node twice as broad as long, sides and front hemispherical, straight behind; in profile higher than long, anterior face vertical, slightly convex, posterior face vertical slightly concave, dorsum convex, as long as posterior face, both edges rounded; ventral process large, as long as broad, a large transparent puncture in the middle at base, the process is furnished with two large sharp spines, one in front directed downward, the other at the posterior corner and directed backward. Postpetiole one-third broader than long, sides and front feebly convex, angle rounded; constriction wide and shallow. First segment of gaster broader than long. Legs robust.

Male and female unknown.

Habitat.—Northern Territory: Koolpinyah (C. L. Barrett, 1933).

Not near any of the previously described species, but the size and colour are similar to those of *C. tasmaniensis* Em.

Subfamily **Dolichoderinae** Forel.
Zeitschr. Wiss. Zool., xxx, Suppl., p. 54, 1878.

Genus IRIDOMYRMEX Mayr.
Verh. Zool. bot. Ges. Wien, xii, p. 702, 1862.

Iridomyrmex viridigaster sp. nov.
Plate XIII, Fig. 18.

Worker. Length 4·5 mm.

Posterior two-thirds of head, epinotum, node and legs brown; mandibles,

clypeus, antennal fovea, antennae and tarsi yellowish, pronotum red, mesonotum reddish brown, gaster green.

Mandibles with large, shallow, elongate punctures; head smooth and shining, clypeus, frontal carinae, thorax, node and gaster microscopically reticulate.

Hair yellow, erect, short and sparse throughout, pubescence very fine and adpressed, abundant throughout, particularly on the gaster where it forms a fine yellowish covering.

Head as long as broad, occipital border short and straight, sides strongly convex. Mandibles furnished with numerous strong sharp teeth. Clypeus convex both ways, anterior border straight or feebly concave, the angles rounded, the posterior edge rounded and continued backward between the frontal carinae, very slightly depressed at the middle. Frontal carinae short and parallel, as long as broad, a sharp longitudinal carina in the centre. Scapes not extending to occipital border by fully their thickness; first segment of funiculus three times longer than second, remainder sub-equal, apical as long as the two preceding combined. Eyes large, flatly convex, placed at middle of sides. Thorax twice as long as broad through pronotum, sutures well defined. Pronotum one-third broader than long, strongly convex in all directions. Mesonotum as long as broad, pear-shaped, broadest in front, constriction between mesonotum and epinotum deep and wide with the spiracles prominent on top at each side. Epinotum as long as broad, strongly convex laterally, sides almost parallel; in profile pronotum and mesonotum united, hemispherical, suture faintly indicated, meso-epinotal suture sharp and deep. Epinotum convex above, declivity concave below, strongly rounded into dorsum above, as long as dorsum, spiracles prominent. Node scale-like, four times broader than long, sides convex, straight in front and behind; in profile twice as high as long, parallel to near top, anterior face straight, top edge sharp, posterior face rounded into dorsum above. Gaster slightly longer than broad,first segment one and three-quarters times broader than long and three times broader behind than in front, truncate in front with a small cavity which fits the node, anterior face short and straight, sides convex, legs long and slender.

Male and female unknown.

Habitat.—Victoria: Patho (H. A. Potter).

In size and colour this species is intermediate between *I. rufoniger* Lowne and *I. viridaeneus* Viehmeyer.

Subfamily **Formicinae** Lepeletier.
Hist. Nat. Ins., Hymn., i, p. 197, 1836.

Genus MELOPHORUS Lubbock.
Jour. Linn. Soc. Lond., Zool., xvii, p. 51, 1883.

Melophorus fulvihirtus sp. nov.
Plate XIII, Figs. 19-21.

Worker major. Length 5·7 mm.

Reddish yellow. Head, mandibles and antennae castaneous. Mandibles shining, coarsely striate longitudinally. Head, thorax and node very finely

and densely reticulate, with numerous very small, shallow piligerous punctures. Gaster and legs shining, more superficially reticulate and the fine punctures more abundant.

Hair yellow, erect, very short and abundant throughout. A row of very long erect yellow hairs on anterior edge of clypeus and a tuft of somewhat shorter hairs at apex of gaster.

Head one-fourth broader than long, broader behind than in front, occipital border slightly concave in middle, angles broadly rounded, sides convex. Mandibles large and broad, furnished with five or six large sharp teeth. Clypeus strongly convex in middle, concave at sides near antennal fovea, projecting and convex in front. Frontal area small and triangular. Frontal carinae one-third broader than long, rather flat, parallel; antennal insertions exposed in front; a shallow median groove extends to anterior ocellus, there is a small polished ocellus-like tubercle midway along the groove. Scapes extend backwards to the occipital border; first and second segments of funiculus equal in length, third to tenth shorter and subequal, apical as long as the two preceding combined. Eyes circular, feebly convex, their anterior edge at middle of sides. Ocelli very small. Thorax one-third longer than broad. Pronotum twice as broad as long, strongly convex in all directions, pro-mesonotal suture sharp and deep. Mesonotum slightly broader than long, sides and posterior border convex, with a triangular excision at middle of posterior border, dorsum weakly convex both ways, a broad blunt tubercle at the posterior third on each side; constriction between mesonotum and epinotum deep. Epinotum four times broader than long, the posterior angles produced as broad blunt tubercles; in profile pronotum convex and dipping in front, pro-mesonotal suture sharply defined. Mesonotum convex, higher than pronotum, posterior angles raised. Epinotum much lower than mesonotum, declivity straight, at an obtuse angle, fully three times longer than dorsum. Node four times broader than long, scale-like, anterior face convex, posterior face straight or feebly convex, superior edge blunt, deeply concave in middle; in profile three times higher than long, anterior and posterior faces convex, bluntly pointed above. Gaster as broad as long; first segment three times broader than long, strongly convex in front. Legs robust.

Worker media. Length 5 mm.

Colour, sculpture and pilosity similar to the worker major, from which it differs only in being smaller and more slender and the antennae slightly longer. Node feebly concave on top.

Worker minor. Length 3·7 mm.

Colour and sculpture as in the major, but mandibles not coarsely striate. Pilosity coarser and more abundant, very short and erect, bristle-like, shorter and suberect on scapes, none on funiculus.

Head one-fourth broader than long, occipital border straight, angles rounded, sides convex. Mandibles, clypeus, frontal area and frontal carinae as in major worker. Scapes extend beyond the occipital border by more than half their length, all segments of funiculus equal in length but apical slightly longer. Ocelli minute. Thorax similar but tubercles on mesonotum and epinotum feebly indicated. Node more slender. Gaster longer and narrower.

Male and female unknown.

Habitat.—Victoria: Patho (H. A. Potter).

A very distinct species readily distinguished by the angular thorax. This ant was observed, by Mr. Potter, to carry larvae and pupae from the nest of *Iridomyrmex detectus* Smith.

Genus CAMPONOTUS Mayr.
Europ. Formic., p. 35, 1861.

Subgenus TANAEMYRMEX Ashmead.
Canad. Entom., p. 384, 1905.

Camponotus (Tanaemyrmex) tricoloratus sp. nov.
Plate XIII, Figs. 22, 23.

Worker major. Length 15·5-17mm.

Head and last four segments of gaster brown; cheeks, antennae, first segment of gaster and tarsi reddish brown, head with a broad black longitudinal strip behind; sides of the clypeus and frontal carinae black; thorax, node and legs yellow, pronotum darker.

Mandibles densely punctate-reticulate, with numerous large shallow piligerous punctures, obliquely striate at base of teeth. Head very finely and densely reticulate-punctate, the punctures small and obsolete. Thorax, node and gaster shining, very finely reticulate.

Hair reddish, long and erect, sparse throughout, there is a row of very long hairs at the base and at the apex of each segment of gaster, extra long at apex of gaster, shorter and stouter on legs, bristle-like on under-sides of tibiae and tarsi, none on antennae. Pubescence very fine and adpressed. Very sparse throughout.

Head almost as broad as long, anterior fourth of sides convex, straight and parallel behind, occipital border concave, angles rounded. Mandibles broad, convex above, furnished with numerous strong teeth. Clypeus slightly broader than long, dorsum flatly convex, anterior border strongly produced, straight in front, strongly crenulate, with seven or eight broad tubercles. Frontal area small. Frontal carinae one-fifth longer than broad in the middle, broader behind than in front. Scapes extend beyond the occipital border by their thickness; first three segments of funiculus equal in length, two and one-half times longer than broad. Eyes small, flatly convex, placed on front of head behind the middle. Ocelli small. Thorax twice as long as broad, sutures sharply impressed. Pronotum two and one-fourth times broader than long, strongly convex. Mesonotum one-seventh broader than long, broadest in front, strongly convex transversely. Mesonotum two and one-half times broader than long, oval. Epinotum one-third longer than broad, convex laterally; in profile pronotum and mesonotum strongly and evenly convex, suture sharply impressed, epinotum concave in the middle of dorsum, three-fifths longer than the declivity into which it is rounded. Node three and one-half times broader than long, strongly convex in front, straight behind; in profile higher than long, almost triangular, anterior face convex, erect, posterior face straight, raised and ascending at an obtuse angle, the top sharp. Gaster one-third longer than broad. Legs long and robust.

Worker minor. Length 12·5-14 mm.

Head black; mandibles, clypeus and antennae reddish brown; thorax, gaster and tarsi brownish yellow, legs yellow.

Sculpture and pilosity as in the worker major.

Head one-third longer than broad, three times broader in front than

behind, produced backward neck-line, sides feebly convex. Mandibles as in the major, but the teeth strong. Clypeus strongly raised longitudinally in the middle, subcarinate, the denticles on anterior border smaller and more obsolete. Frontal carinae narrower, particularly in front. Scapes extend beyond the occipital border by half their length; third and fourth segments of funiculus one-fourth longer than first and second. Eyes large, globular, placed behind the middle of sides. Thorax three times as long as broad, sutures sharply impressed. Pronotum as long as broad, cone-shaped, broadest behind. Mesonotum as long as broad in front, twice as broad in front as behind. Mesonotum one-fourth broader than long, oval. Epinotum one-third longer than broad; in profile dorsum similar to that of the major but the epinotum longer and the declivity shorter, dorsum twice as long as declivity. Node one-fifth longer than broad, oblong, sides straight and parallel, anterior and posterior faces silghtly convex, angles rounded; in profile as long as high, almost triangular, anterior faces convex directed backward, posterior face feebly convex directed forward, top sharp pointed. Gaster barely twice as long as broad. Legs long and slender.

Male and female unknown.

Habitat.—Victoria: Near Mildura (Mrs. M. J. Zimmer).

Near *C. (T.) spinitarsus* Emery, but is distinguished by the shape of the thorax and node.

Genus POLYRHACHIS Smith.

Journ. Linn. Soc. Lond., Zool., ii, p. 58, 1857.

Subgenus Myrmhopla Forel.

Arkiv. f. Zool., ix, p. 107, 1915.

Polyrhachis (Myrmhopla) exulans sp. nov.

Plate XIII, Fig. 24.

Worker. Length 5·5-6 mm.

Black throughout, legs somewhat brownish black.

Mandibles shining, with scattered piligerous punctures. Head, thorax and node finely and very densely reticulate; scapes, legs and gaster more finely and superficially reticulate.

Hair yellow, erect, confined to clypeus and apical segments of gaster. Pubescence white, very fine and adpressed, abundant throughout, longer and more abundant on gaster forming a distinct covering almost hiding the sculpture.

Head as long as broad, almost circular. Mandibles furnished with large sharp teeth. Clypeus twice as broad as long, broadly convex, produced convex in front with a broad triangular depression in the middle. Frontal area triangular. Frontal carinae almost twice as long as broad, as broad in front as behind, concave in the middle. Scapes extend beyond occipital border by fully half their length; first segment of funiculus one-seventh longer than the three following. Eyes placed behind middle of sides. Thorax one and three-fifths times longer than broad, pro-mesonotal suture

sharply impressed. Pronotum, on dorsum, very slightly broader than long, sides straight, sharply rounded but not margined, convex in front, each anterior angle furnished with a long sharp spine, twice as long as broad at base, directed outward and slightly forward and upward. Mesonotum slightly broader than long, convex in all directions. Epinotum broader than long, convex laterally, posterior angles each furnished with a long slender sharp spine, three times as long as broad at base, their distance apart at base equal to half their length; in profile slightly and abruptly raised convex in front, straight and sloping behind in middle, basal fourth convex, anterior spines directed forward. Mesonotum convex. Epinotum straight, slightly shorter than the declivity, posterior spines slender directed upward and backward, declivity straight. Node twice as broad as long, each angle furnished with a long sharp spine encompassing the gaster, fully three times longer than broad at base, curved outward and backward; in profile higher than long, twice as broad at base as on top, anterior face vertical and straight, posterior face convex directed forward and upward. Gaster slightly longer than broad. Legs long and slender.

Male and female unknown.

Habitat.—Northern Territory: Koolpinyah (C. L. Barrett, 1933).

Smaller and more slender than *P. (M.) clotho* Forel, the sculpture and pilosity also are different.

Subgenus Campomyrma Wheeler.
Science, xxxiii, p. 360, 1911.

Polyrhachis (Campomyrma) zimmerae sp. nov.
Plate XIII, Fig. 25.

Worker. Length 11-12 mm.

Black; mandibles, clypeus, funiculi and legs reddish brown.

Head, thorax and node finely and densely reticulate, gaster more finely and densely reticulate.

Hair yellow, long and erect on mandibles, clypeus and apex of gaster, none elsewhere on body, short and suberect on antennae and legs. Pubescence nil.

Head one-ninth longer than broad, sides and occipital border feebly convex, angles rounded, lateral border sharp from margin of eyes to occipital border. Mandibles furnished with four or five strong sharp teeth. Clypeus large, one-third of length of head, anterior border broadly produced, furnished with numerous short, sharp teeth-like spines in front. Frontal area, small and triangular. Frontal carinae one-third longer than broad behind. Antennal insertions exposed. Scapes extend beyond occipital border by fully half their length; second, third and fourth segments of funiculus equal in length, slightly shorter than first, apical barely as long as first. Eyes large, placed about one-third of their diameter from the posterior border. Thorax fully twice as long as broad, sides strongly margined, sutures sharply impressed. Pronotum, across the spines, about one-third broader than long, convex in front, the angles produced laterally as broad sharp spines, sides slightly convex in middle, lateral borders

sharp, dorsum flatly convex. Mesonotum almost as long as broad, broadest in front, flattened behind. Epinotum one-third longer than broad, sides parallel, feebly convex, lateral margins sharp and raised, terminating on each side in a long slender spine, twice as long as broad at base; in profile pronotum and mesonotum forming an evenly convex arch, suture sharply impressed, dorsum higher than lateral margins, anterior spine very slightly directed forward, anterior fourth of epinotum convex, straight behind, dorsum one-third longer than declivity, terminal spine long, slender and sharp, directed backward very slightly upward, declivity straight, at an obtuse angle. Node as long as broad, square, the four borders straight, posterior angles produced as long thin spines curved backward and slightly outward, fully three times as long as broad at base, between these long outer spines are two tubercles, on some examples these rudimentary spines are distinct, on others they are indistinct; in profile anterior and posterior faces vertical, posterior face twice as high as anterior face, dorsum straight, raised at an obtuse angle, posterior spines slender, directed upward and backward. Gaster almost circular, one-sixth longer than broad. Legs long and slender.

Habitat.—New South Wales: Mt. Manfred (Mrs. M. J. Zimmer).

This species belongs to the group containing *P. (C.) macropus* Wheeler and *P. (C.) phyrne* Forel.

Plate XIII.

Fig. 1. Phyracaces crassus sp. nov. Worker.
Fig. 2. dromus sp. nov. Worker.
Fig. 3. dromus sp. nov. Female.
Fig. 4. Neophyracaces potteri sp. nov. Worker.
Fig. 5. potteri sp. nov. Male.
Fig. 6. gwynethae sp. nov. Worker.
Fig. 7. gwynethae sp. nov. Male.
Fig. 8. macrops sp. nov. Worker.
Fig. 9. piliventris sp. nov. Worker.
Fig. 10. Rhytidoponera barretti sp. nov. Worker.
Fig. 11. greavesi sp. nov. Worker.
Fig. 12. rufithorax sp. nov. Worker.
Fig. 13. Chalcoponera viridis sp. nov. Worker.
Fig. 14. flavipes sp. nov. Worker.
Fig. 15. hilli sp. nov. Worker.
Fig. 16. pulchra sp. nov. Worker.
Fig. 17. brunnea sp. nov. Worker.
Fig. 18. Iridomyrmex viridigaster sp. nov. Worker.
Fig. 19. Melophorus fulvihirtus sp. nov. Major Worker.
Fig. 20. fulvihirtus sp. nov. Media Worker.
Fig. 21. fulvihirtus sp. nov. Minor Worker.
Fig. 22. Camponotus (Tanaemyrmex) tricoloratus sp. nov. Major Worker.
Fig. 23. tricoloratus sp. nov. Minor Worker.
Fig. 24. Polyrhachis (Myrmhopla) exulans sp. nov. Worker.
Fig. 25. (Campomyrma) zimmerae sp. nov. Worker.

Australian Formicidae; new species

CORMORANTS AND THE GIPPSLAND LAKES FISHERY.

By George Mack,
Ornithologist, National Museum of Victoria.

Figs. 1-15.

In all parts of Australia Cormorants or Shags are condemned out of hand as pests. They are constantly harried, shoots are organized, and there is even a body of people in Melbourne whose purpose is the "sport" of organized killing of these birds. Being gregarious, the Cormorant is an easy mark when the guns are numerous, particularly so during the breeding season when adults with eggs or young in the nest must return to the rookery. All this because the Cormorant naturally seeks its food from river, estuary, lake and sea, where it and its kind have obtained their food for countless thousands of years.

It is usual, unfortunately, when matters go wrong, as when there is a diminution in a natural product, to attribute the damage to a handy culprit or supposed cause, rather than to ascertain the actual cause and take suitable action. When the commercial fishermen of the Gippsland Lakes found that the quantity of marketable fishes was decreasing, some of them saw in the presence of Cormorants the cause of their impoverishment; not a surprising conclusion, perhaps, when it is remembered that fishing is these men's livelihood, and they felt impelled, without guidance, to name a cause of their loss.

In 1938, at the request of the Department of Fisheries and Game, Victoria, it was arranged that I should endeavour to investigate the relationship of Cormorants to the fishery by an examination of stomach contents. The resident inspector of the Department at Bairnsdale (Mr. T. G. Yates) was assigned the work of obtaining the necessary specimens and I instructed him in methods of dissecting, sexing and transporting the material. As the collecting of the birds had to be done by the inspector in addition to his normal duties, which are varied and erratic as to time, he was unable to obtain as much material as I would have liked, but bearing in mind the difficulties of constant collecting and the unattractive nature of the work, to Mr. Yates and those local residents who helped him on occasion much credit and thanks are due.

Records of the annual number of men and boats employed

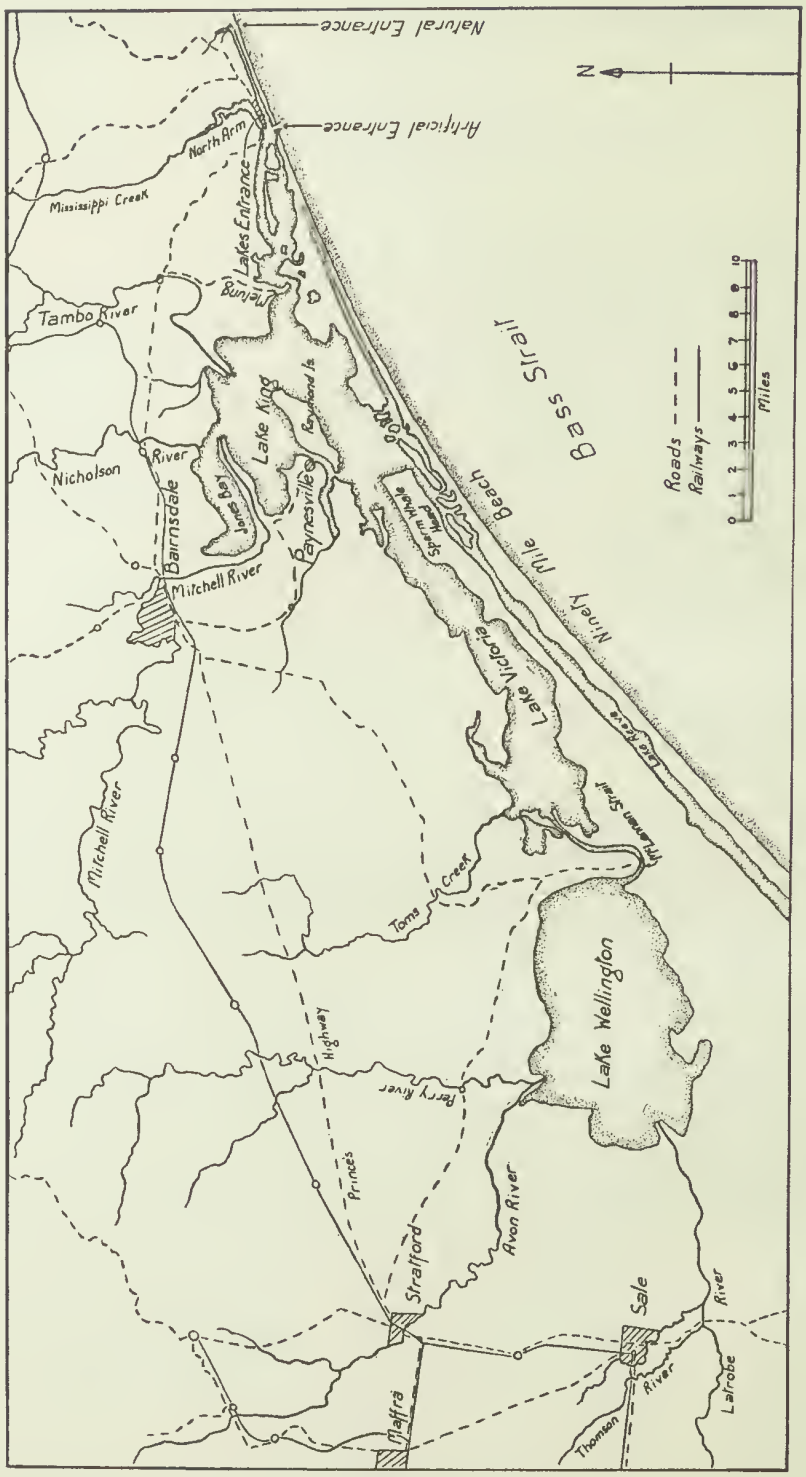


FIG. 1.
The Gippsland Lakes Area, south-eastern Victoria, Australia. G.M. del.

at, and quantities of fishes marketed from, all East Gippsland inlets were extracted from records supplied by the Department. These figures have been kept from 1911 onwards.

I should like to record my appreciation of the co-operation of many fishermen during brief visits to the lakes, and to acknowledge helpful information readily given by Mr. A. J. Gilsenan of Paynesville.

The Gippsland Lakes are situated in the plains of south-eastern Victoria, and are separated from the sea only by sand dunes. The plains consist of Cainozoic marine and continental deposits, chiefly of Tertiary age, to a depth of close on 1,500 feet as shown by bores at Lakes Entrance. Much movement and sagging has taken place in the area from Tertiary times onwards, and the formation of the lakes is due to the drowning of a relatively depressed area which includes the mouths of five major streams and some smaller creeks. The major streams, the Tambo, Nicholson, Mitchell, Avon and Latrobe rivers, drain a considerable area to the north and west of the lakes, south of the Main Divide, and are of the utmost importance to the fishery.

The area of the lakes proper is approximately 160 square miles, extending about fifty miles east and west with a maximum breadth north and south of ten miles. The western end, near which the town of Sale is situated, is about 140 miles east of Melbourne.

These lakes form the most important estuarine fishery in Victoria, and although marine fisheries using modern plant and methods may yet be developed in this State, it is probable that this area will retain its importance, providing that the fishery is preserved.

Historical.

The following brief historical outline is included here because of its bearing on the artificial entrance channel to the lakes, a vital matter to the fishery of the present.

The settlement of south-east Gippsland commenced in 1840 by penetration from the north. The desire for new pastures provided the impetus; but at that period the country in general was heavily timbered, and markets and suitable transport were lacking. About the only means of communication with Melbourne was by sailing boat, so that anything approaching fairly intensive settlement was not possible. In 1878 the railway from the capital to Sale at the western end of the lakes was opened, and from then development has been continuous. With the advent of the railway, and with

steamers sailing the lakes and rivers, the fishery became a commercial proposition.

It is interesting and essential to record here that even at that period, about forty years after the first settlement, fishes were exceedingly plentiful, various species of ducks and other water birds were said to cloud the sky, and the vegetation both in and around the lakes was prolific. There is still living at least one man who, at that time, commonly shot as many as eighty pairs of ducks per day for the Melbourne market. As evidence of the abundance of fishes, the following information is taken from the third edition of a small publication by John King (Our Guide to the Gippsland Lakes and Rivers, 1886) in which he describes a visit to the lakes. The author states that on the return journey to Sale the steamer carried 10½ tons (23,520 lb.) of fishes, the result of one morning's catch. He records that one fisherman in one haul obtained 4,000 lb., chiefly Gippsland Perch (*Percalates colonorum* (Günth.)), valued at about £70-£80. Apparently Black Bream (*Sparus australis* (Günth.)) and Gippsland Perch were the main species, and another record is given of about 6,000 lb. of these two species being taken in one haul.

Although at that time the natural bar at the mouths of most of the rivers had been removed, the main sand bar between the sea and lakes was still intact, notwithstanding that between 1870-80 considerable sums had been spent in efforts to construct a permanent entrance, in order that ships of a certain draught might enter the lakes from the sea at all times. With the railway available, it is difficult to understand why this was sought, for at most only small ships of very light draught could be accommodated.

In 1881 Sir John Coode, the well-known harbour engineer, submitted a report with plans for the construction of an opening at an estimated cost of £85,700. Work according to these plans was undertaken and in 1889 the artificial channel between sea and lakes, some three or four miles west of the natural entrance, was completed. In the following years with the extension of the railway beyond Sale, the building of good roads, and the marked improvement in transport facilities generally, the use of the entrance for transport purposes diminished and finally ceased about five years ago. It may have been of some little importance to the relatively few people in the vicinity of Lakes Entrance (then Cunninghame) in the early years, but now no outside steamer calls. The channel, however, is still maintained in good order and repair.

FIG. 2.
Gippsland Lakes fishery, 1911-1937. Men and boats employed and quantities of all fishes marketed annually.

Fishes Marketed.

There are twelve species of fishes of greater or less commercial importance to the fishery. These are here set down in three groups, each of which is briefly discussed in relation to the quantities of each species marketed from 1911 to 1937 inclusive as shown on the graphs. A few other species are obtained, notably Sand (Poddy) Mullet (*Myxus elongatus* Günth.), Sharks (*? Mustelus* sp.), Leatherjackets (*? Cantherines* sp.), and Kingfish (*Seriola grandis* Cast.), but the supply of these in general is erratic and the quantities such as to be relatively unimportant.

Names of fishes are according to A. R. McCulloch, *Check-list of Fishes recorded from Australia,* Memoir V, 1929-30, Australian Museum, Sydney.

1. Barracouta *Thyrsites atun* (Euphr.).
   Snapper *Pagrosomus auratus* (Bloch and Schn.).

These two species are obtained some miles to sea outside the lakes. In these circumstances, fishing is greatly controlled by the weather for only comparatively small boats are used, and this probably accounts, at least in part, for the variation in supply.

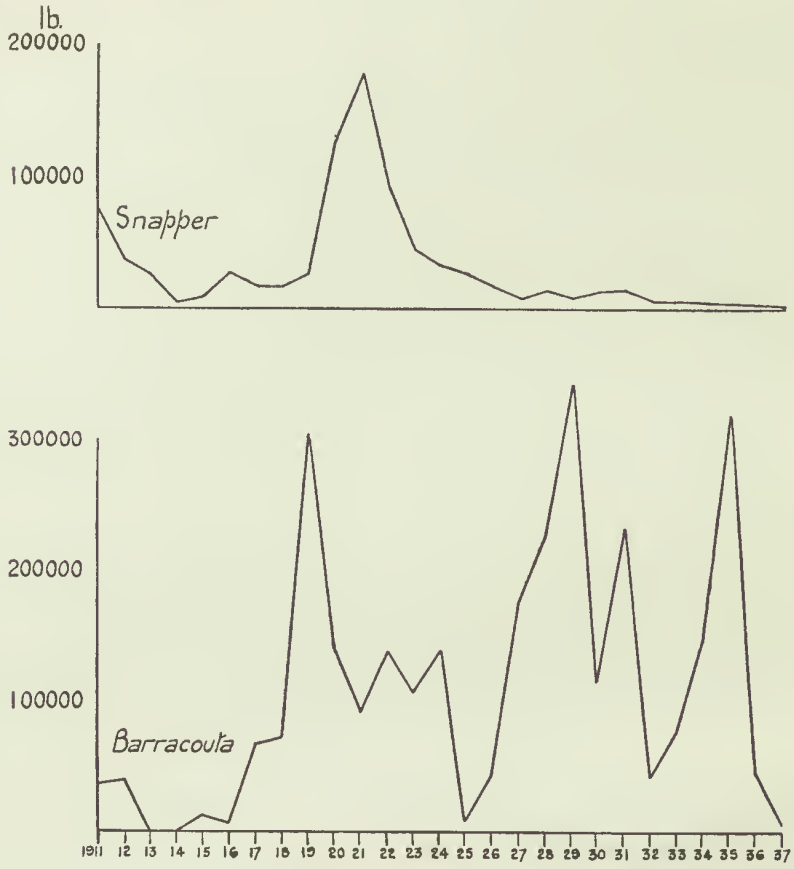


FIG. 3.
Snapper and Barracouta marketed annually from the Gippsland Lakes, 1911-1937.

The main fact in connection with this group is that neither species is in any way affected by conditions within the lakes and rivers, and are of no direct concern in any discussion of the lakes fishery proper.

2. Lake Mullet *Agonostomus forsteri* (Cuv. and Val.).
   Salmon Trout *Arripis trutta* (Bloch and Schn.).
   Trevally *Caranx georgianus* Cuv. and Val.

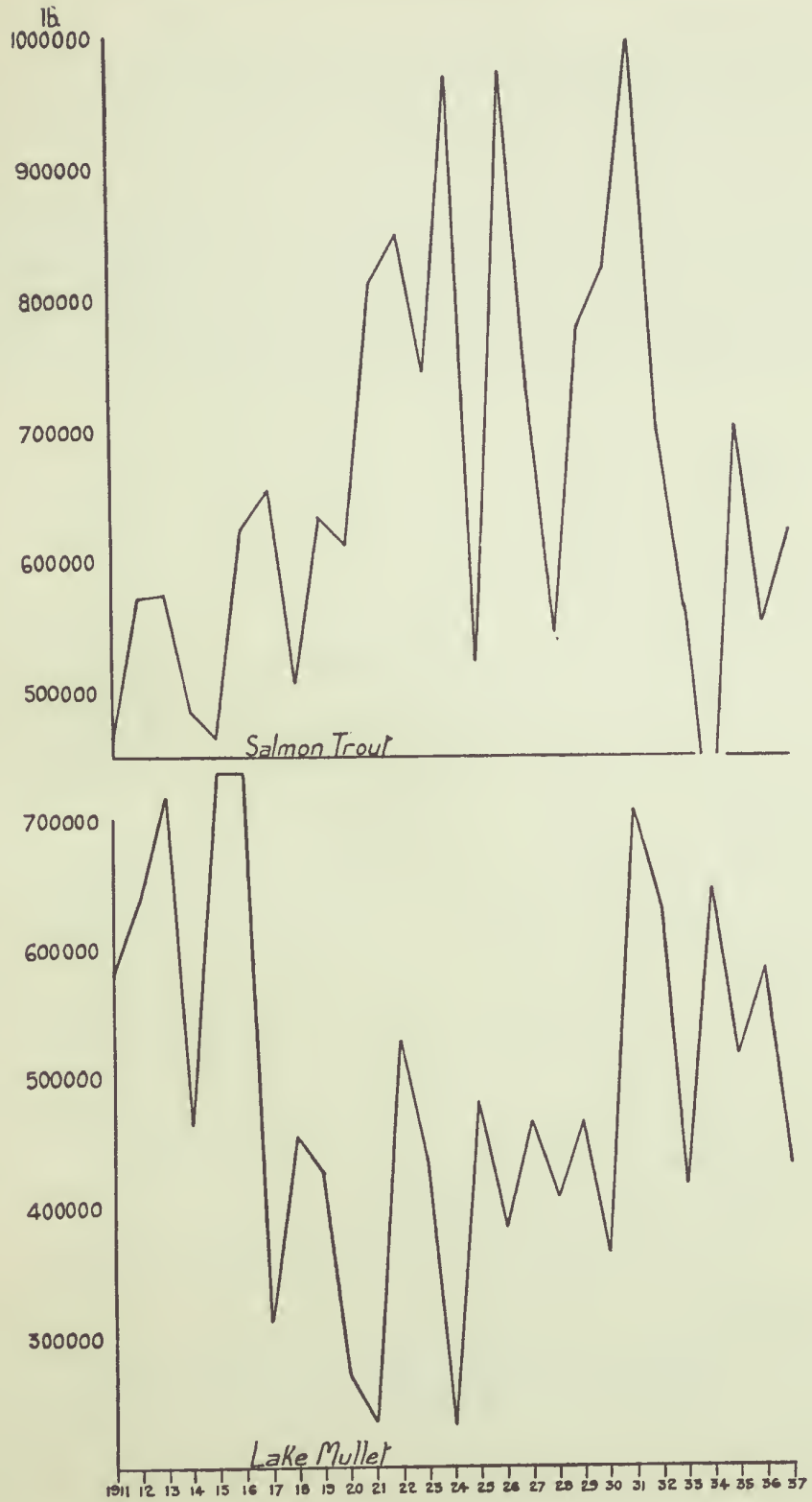


FIG. 4.

Lake Mullet and Salmon Trout marketed annually from the Gippsland Lakes, 1911-1937.

Skipjack *Pomatomus saltator* (Linn.).
Short-finned Eel *Anguilla australis* Rich.
Flounder, chiefly *Rhombosolea tapirina* Günth.
Sand Flathead *Platycephalus bassensis* Cuv. and Val.

The above seven species are netted in the lakes, but so far as is known, none of them spawn in the lakes or rivers. This being the case, and the statement is made with considerable assurance, it will be evident that they are independent of the conditions in the estuary at the most critical period of life.

In quantity, Lake Mullet and Salmon Trout are out-

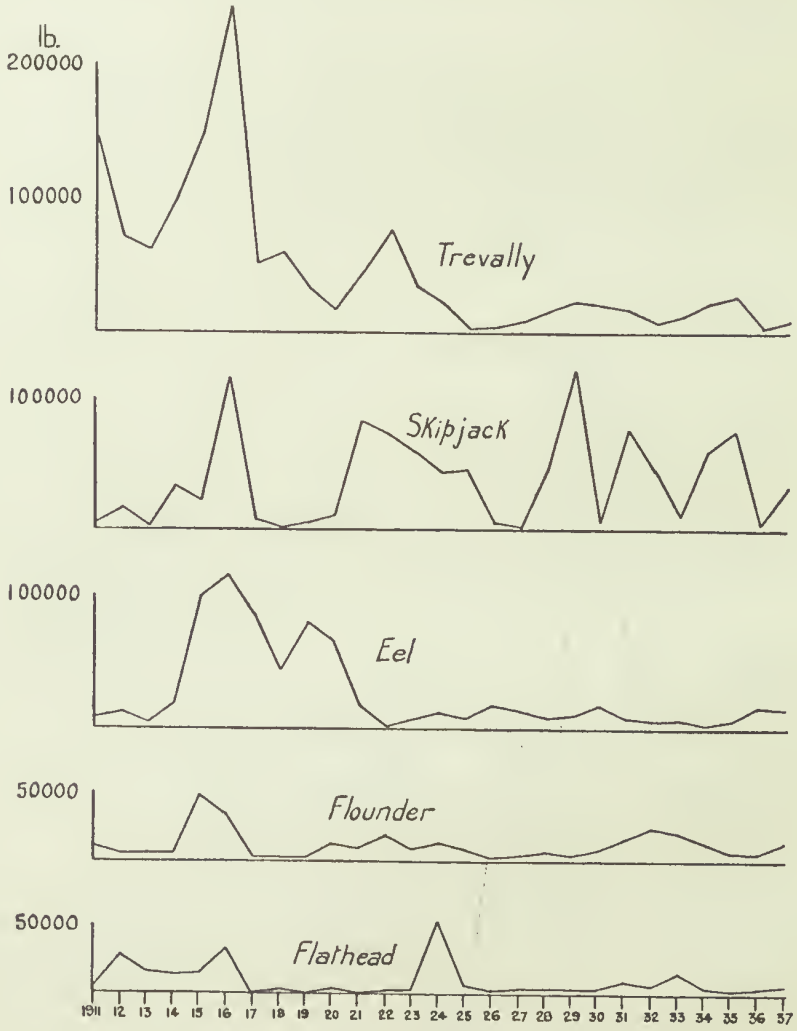


FIG. 5.

Five species marketed annually from the Gippsland Lakes, 1911-1937.

standing, and there has been no diminution during the period for which figures are available. Amounts of the other five species have never been large and the graphs show fairly usual variation but no marked reduction except in the case

FIG. 6.
Black Bream marketed annually from the Gippsland Lakes, 1911-1937.

of Trevally. It may be noted that all show a decided rise in 1916, a record quantity of two species. This was a year of extreme flooding in rivers flowing into the lakes and there is here, obviously, a direct connection between the effect of great volumes of fresh water and the numbers of the species of this group entering the lakes from the sea.

3. Black Bream *Sparus australis* (Günth.)
   River Garfish *Hyporhamphus regularis* (Günth.)
   Ludrick *Girella tricuspidata* (Quoy and Gaim.).

Although details of the spawning of any of the fishes mentioned in this paper are unknown, there is considerable evidence indicating that the three species of this group are wholly dependent upon the lakes and other similar inlets from the egg stage to maturity. This is a very important point, for it will be apparent that any marked alteration in the natural condition of the lakes will seriously affect these fishes. The graphs show that the diminution in the supplies

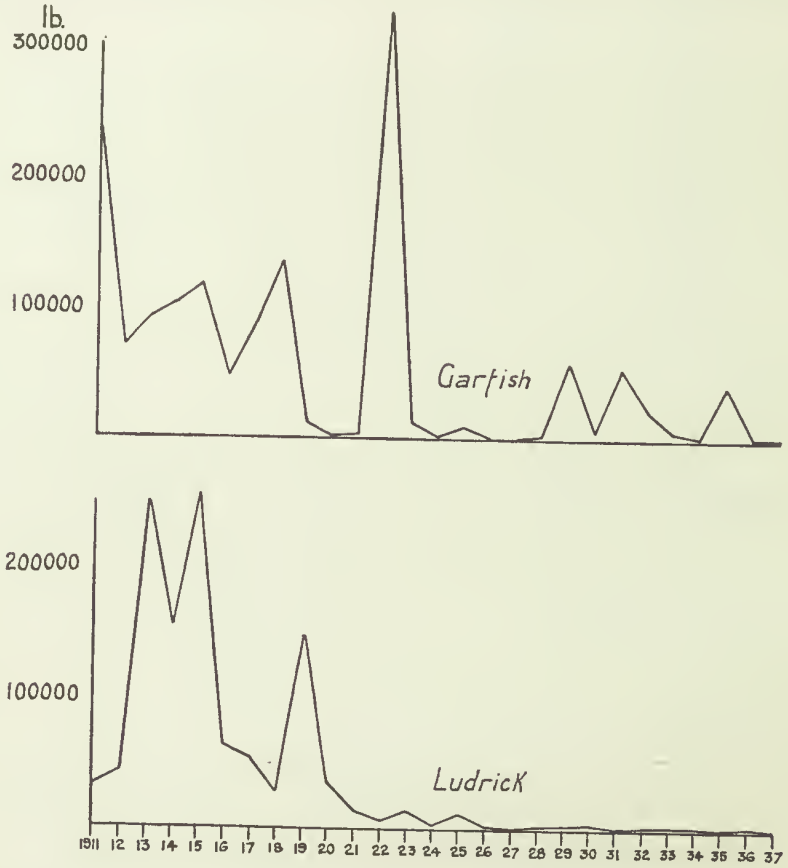


FIG. 7.
River Garfish and Ludrick marketed annually from the Gippsland Lakes, 1911-1937.

of this group is mainly responsible for the reduced total annual quantity, and moreover, the choicest fish of the lakes, the Black Bream, has been most affected in this respect. The Bream occurs in the diet of the Large Black Cormorant

(*P. carbo*), but I do not consider this even to be a contributing factor. Conditions in the waters of the estuary are the dominant factors in the case of species whose whole life-cycles are completed within the area. This matter is referred to more fully following a statement of the results of Cormorant stomach examinations.

With regard to the spawning of fishes there is an aspect which, although elementary, might well be restated here because of its great importance to a proper appreciation of economic work. A female fish in spawn produces a large number of ova or eggs. The number varies with the species, and in some instances runs into millions from one fish. It will be apparent that if all fertilized ova reached maturity, in a very brief time fishes would be so numerous as to make life in the sea impossible. Perfect natural interlocking controls prevent this, and even in those species in which a single female produces millions of ova, on the average, only two attain maturity and spawn, thus maintaining but not increasing the numbers of any one species. The remainder in general are eaten by other organisms either as eggs or at some stage before reaching maturity. Probably the least among the many natural controls are various species of birds, and the common attitude of many people that because a certain kind of bird feeds partly or entirely on fishes it is of necessity a harmful species, is entirely wrong and indefensible. This is an indication of what is intended when it is stated that under natural conditions a natural balance or equilibrium, is maintained.

Stomach Examination Results.

Of five species of Cormorants or Shags occurring in Australia, four are known from the Gippsland Lakes. They are as follows:—

Large Black Cormorant		*Phalacrocorax carbo novaehollandiae* Steph.
Small Black	„	*Phalacrocorax sulcirostris* (Brandt).
Yellow-faced Pied	„	*Phalacrocorax varius* (Gmel.).
Small Pied	„	*Microcarbo melanoleucus* (Vieill.).

Outstanding in size and numbers is the Large Black, the species with which this paper is concerned. Next in numbers is the Small Pied, followed by a more meagre population of the Small Black, and finally a very few Yellow-faced Pied.

It is possible that the fifth species, the Black-faced Pied (*Phalacrocorax fuscescens* (Vieill.)) occurs as an occasional visitor, but so far no specimen has been taken.

It was obvious from the beginning that only the Large Black and Small Pied were likely to be of any importance to the work in hand, the other two being too few in numbers to warrant consideration. Soon after the examination of stomach contents was commenced it became apparent that the Small Pied also was of no consequence in so far as edible or marketed fishes were concerned. Thus the collecting and examination of the Large Black Cormorant received most attention and no other species is included in the results that follow.

It is necessary to make clear that the Cormorant populations on the lakes are not permanent throughout the year. The first record of any species nesting in the area was made in 1939 when, I am informed, a small rookery of Yellow-faced Pied was discovered. All other species apparently leave the lakes for breeding, and therefore are present in considerable numbers during only a part of the year.

For the purpose of this investigation I should like to have obtained about 25-30 specimens of the Large Black Cormorant per month throughout the year. This number would have given a very good cross-section of the food, and it is what was aimed at but not quite attained. However, more than 200 stomachs of the Large Black alone were examined, and practically all were collected during the six months when the birds are most numerous on the lakes. During the three months November, December, January, when no specimens were obtained, the number of these birds on the lakes must be negligible.

The volumetric or percentage by bulk method is employed here to record the stomach contents. This involves the determination and sorting out into separate masses of the different species of organisms present in any one stomach. This completed, the smallest mass is taken as a unit and from it the volume percentage of each species of organism is determined. It is the method adopted by the majority of workers, and has been used consistently by the Bureau of Biological Survey of the United States Department of Agriculture, the work of which, both in amount and execution, is outstanding.

A few workers, including D. L. Serventy in a recent paper (*The Emu,* xxxviii, 1938, pp. 293-316) use the numerical

method. Essentially this consists of counting and recording the number of individuals of each species of organism in each stomach, quite irrespective of size. For instance, the stomach of a Large Black Cormorant will be distended, more than full, with one Black Bream (marketed) measuring 240 mm. (9½ in.) in total length, and another similar stomach may contain when full about 70 Anchovies or Gobies (non-marketed). By the numerical method as employed by Serventy this would be as 70 to 1 in favour of the non-marketed form and therefore in favour of the Cormorants, whereas by the volumetric the result would be as 1 to 1. Because of the general disparity in size between marketed and non-marketed fishes, the numerical method tends to favour the case for the birds, but above all, it signally fails to give any proper conception of the part played by the different kinds of organisms in the birds' diet. On the other hand, the volumetric method does provide this information. The counting of individual organisms may be used with advantage to stress a point, and throughout this work a count has been made for the purpose of helping to interpret the percentage results.

This matter has been discussed at some length since very little of this kind of work has yet been done in Australia, and it is a matter for regret that I find myself unable to accept as a working basis the numerical method as recently used by Serventy. The various methods of estimating the stomach contents of birds are ably discussed by W. L. McAtee in *The Auk,* xxix, 1912, pp. 449-464.

The results of stomach examinations of the Large Black Cormorant for each month of 1939 for which material was received is set out below, with diagrams showing the volume percentage of each food species. Almost without exception the birds were collected during the afternoon and early evening.

In addition to the marketed fishes already named, the following species of non-marketed fishes and crustacea occur in the results. Only the common names are used in the text and diagrams, and it will be noted from the list that the term Gobies covers three species of these small fishes which were easily separated in the stomach contents, but separate treatment here does not seem warranted.

Fishes—

Anchovy *Engraulis australis* (Shaw).
(The "Smig" of the fishermen.)

Gobies	*Gobius lateralis* Macl., *G. bifrenatus* Kner, and *Mugilogobius galwayi* McCull. and Waite.
Hardyhead	*Atherina microstoma* Günth.
Sprat	*Hyperlophus vittatus* (Cast.).
Gudgeon	*Philypnodon grandiceps* (Krefft).
Galaxias	*Galaxias attenuatus* (Jenyns).
Cobbler	*Gymnapistes marmorata* (Cuv. and Val.).
Lamprey	*Caragola mordax* (Rich.).
Crustacea—	
Crab	*Paragrapsus gaimardii* (M. Edw.).
Prawn	*Leander intermedius* (Stimp.).

February.—Sixteen stomachs received of which eight were empty.

The birds were very scarce, and probably the few present had just returned from breeding, for those collected were in poor condition.

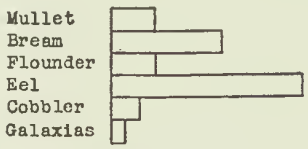


FIG. 8.

February diet; percentage volume of each food species.

The common Short-finned Eel, which is not a food fish of any importance, formed the largest single food item. Two stomachs each contained a single small Bream.

It was recorded that there were "plenty of small Bream about" where some of the birds with empty stomachs were collected.

March-April.—Eight stomachs received of which five were empty.

There was no food fish in the three effective stomachs. One contained 60 per cent. Gobies and 40 per cent. Hardyhead, and two 100 per cent. Gobies.

During these two months the Large Black Cormorant population continued very small, which partly accounts for the small number received. In general the birds were in poor condition and each day they were seen to return to their roosting trees inland from the lakes from 2.30 p.m. onwards. Some of these birds going to roost early were found to have empty stomachs, which is surely remarkable. It appears to

me as indicative of the great difficulty experienced by the Cormorants in catching the average swift-moving food-fish, even when the latter is small.

May.—Sixty-one received of which twelve were empty. The empty stomachs were forwarded merely as examples of many shot in this condition either while roosting or going to roost in the early afternoon.

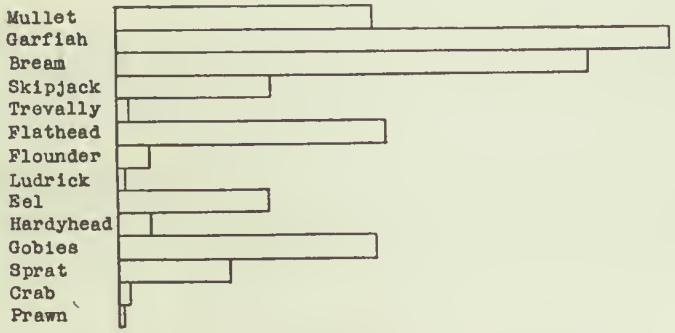


FIG. 9.
May diet; percentage volume of each food species.

Early in the month the birds still were not plentiful and it was remarked, "I do not think there are more than about one thousand birds [Large Black] on the lakes at present." Towards the end of May, however, the number increased considerably. It would appear from the results that because of this increase and the fact that their main food item (Anchovy) was not then available, food fishes entered into the diet to a greater extent than at any other period. The all-important Bream forms about 25 per cent. of the total. The number of effective stomachs received was greater than for any other month.

June.—Thirty stomachs received of which five were empty. The appearance of the Anchovy in the lakes is reflected in the food diagram. Of fourteen out of fifteen stomachs in

FIG. 10.
June diet; percentage volume of each food species.

which this species occurred it represented 100 per cent. of the contents. Bream was present in three examples, representing only 2·94 per cent. of the total stomach contents.

The number of birds apparently reached its height in June, thus synchronising with the arrival in the lakes of the Anchovy.

July.—Twenty-nine effective stomachs received.

The Anchovy is still the largest single item of diet. Bream forms 8·20 per cent. of the total.

The birds continued to return in numbers to roost from 2 p.m. onwards each day. Many more than twenty-nine were shot but those having empty stomachs were not forwarded to me.

It is worthy of note that towards the end of July some birds were assuming the patches of white on the ventral surface characteristic of the breeding plumage in this species.

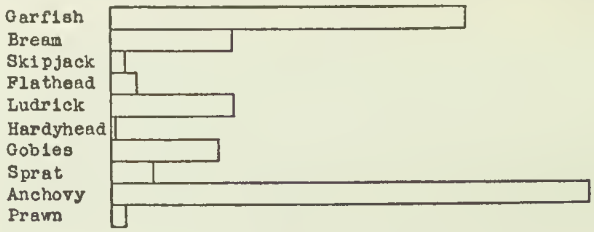


FIG. 11.
July diet; percentage volume of each food species.

August.—Fifteen stomachs received of which one was empty.

Anchovy again exceeds any other single item. Indeed, it is double the total of all other food species. Bream (1) forms 1·05 per cent.

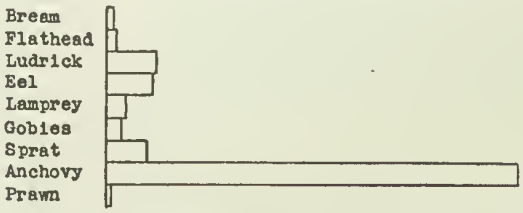


FIG. 12.
August diet; percentage volume of each food species.

September.—Forty-three stomachs received of which eleven were empty. I have added here, however, six specimens

examined in September, 1938 making an effective total of thirty-eight.

Anchovy continues to be the largest single item, but Gobies, Gudgeon, Hardyhead and Sprat form a considerable portion. During this and the following month the first three of these last named small fishes were in spawn and they were probably taken on or near their spawning ground. Six stomachs each contained a single Ludrick, which accounts for the prominence of that species in the diagram. Bream forms 5·24 per cent. of the total.

The condition of the birds at this time was excellent, each stomach being coated with fat to a depth of 10-15 mm. This may reasonably be attributed to the oily nature and high food value of their main items of diet, commencing with Anchovy and passing on to Gobies and other small fishes. Many more birds now had assumed the white plumage patches on the ventral surface first noted in July, and most of those collected showed enlarging gonads.

FIG. 13.

September diet; percentage volume of each food species.

October.—Fourteen effective stomachs received.

It is apparent from the results for this month that the Anchovy must have left the lakes about the end of September.

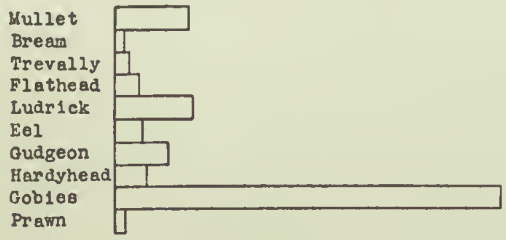


FIG 14.

October diet; percentage volume of each food species.

The Gobies are the chief food item for October and, as noted above, these small fishes were in spawn. Bream forms 1·38 per cent. of the total.

By the end of this month the birds were leaving for their breeding area. It is probable that some had previously gone and that their departure from the lakes takes place over a period similar to their return. I am informed that examples were so scarce as to be practically unprocurable during the next three months, and I can testify that in the course of a few days spent in a section of the area towards the end of January this year (1940), no single Large Black Cormorant was seen.

From the foregoing results alone it will be evident that the depletion of some marketed fishes cannot legitimately be attributed even to the Large Black Cormorant, the most condemned of all species.

During the period when the birds are present on the lakes in greatest numbers a large part of their food consists of Anchovy or Smig, Gobies, Sprat, and other small fishes. It should be noted that the marketed fishes included in the diet comprise both those of which the annual quantities have declined and those which in fact have increased. Of the two species which are outstanding in amounts marketed, the Lake Mullet occurs fairly commonly in the diet, while not one Salmon Trout was found in any stomach examined. It is possible that the latter species enters the lakes only at a late stage of maturity.

Bream forms about 8 per cent. and Anchovy 25 per cent. of the grand total.

Summary

It is remarkable how frequently a particular kind of bird is named as a cause of the destruction of another group of animals or plants. Yet it must be admitted, although it is apparently seldom realised, that previous to settlement in a country such as Australia, both indigenous animals and plants were far more numerous and, what is more important, coexisted in perfect harmony since all are directly or indirectly interdependent.

There is ample evidence that in the Gippsland Lakes area all forms of life, including Cormorants and fishes, were much more plentiful previous to widespread settlement than is the case to-day. Therefore the problem is not just a matter of what constitutes the Cormorants' food, but of what has caused such obviously unbalanced conditions as seriously to reduce

the numbers not only of fishes but of Cormorants and other forms of life. Man alone is the culprit, but with him also lies the counter if action is taken in time. This is a much wider field, and lacking necessary facilities, was beyond what could be accomplished in detail, but at least some aspects could not be ignored.

The graphs of quantities show that there has been a marked decrease particularly in three species of fishes which, unlike the other marketed fishes, appear to be entirely dependent upon the estuary throughout life. In the natural state the waters of the lakes were chiefly fresh to brackish, with increasing salinity only towards the entrance. These conditions were maintained by a natural sand bar between the lakes and the sea which was cast aside when flood waters entered the lakes from the rivers, and mechanically piled up again when the flow was normal, thus at all times keeping the condition of the waters constant. There were similar bars across the mouths of all streams entering the lakes.

Aquatic plants, chiefly grasses, were plentiful, and it is known that the Ludrick feeds on some of these plants, and that they furnish a necessary environment for much of the animal life upon which Bream and River Garfish feed. It is probable too that the aquatic grasses are an essential part of the spawning grounds of all three species. Although so important a link in the chain of vital factors, it was impossible to make a survey of the aquatic vegetation, but as an indication of what appears to be happening, the effect on one of the largest and most common of the plants, the Streaked Arrow Grass (*Triglochin striata* Ruiz.), may be cited as an example. This is a swamp grass which lives in fresh to brackish water, but apparently cannot exist for long in salt water. If, then, an artificial entrance permits the sea to flow freely into the lakes, it may be expected that this and other similar plants will be seriously affected if not destroyed, and if such plants are of considerable importance to the well-being of fishes dependent upon conditions within the lakes, the fishes in turn will be similarly affected if not destroyed. At present the waters of the lakes and for a considerable distance in the rivers are described as being "as salt as the sea." The general effect on the Streaked Arrow Grass has been to destroy practically all growth above bottom level, only the root system remaining. Apparently if flooding is not too long delayed, the root system will survive and fresh growth will be given off. Should the floods be of short duration any new growth will soon again be

killed. This is what would appear to be taking place in the Gippsland Lakes, although probably in a much more complex manner with more serious results than I have indicated. I am informed that the Streaked Arrow Grass can be obtained at the moment (July, 1940) only in a few favourable localities.

With the completion of the artificial entrance in 1889 the more or less constant composition of the waters was destroyed and, as a consequence, the very basis of the natural conditions of the lakes. There is no available written evidence of the effects in the early years, and no record of fish quantities until 1911, but the process would be a gradual one, successfully held in check at times by floods. The greater and more frequent the floods the less the possibility of deterioration by the free access of sea water. The most beneficial year in this respect was 1916, when flooding was severe and prolonged with interesting results as shown in the graphs of quantities.

Towards 1920, however, the effects of what can only be attributed to increased salinity were becoming increasingly evident. Depletion of aquatic grasses was noted, and what was of more immediate concern to the fishermen, by that time a crab (*Paragrapsus gaimardii* (M. Edw.)) had multiplied to such an extent as to make the use of mesh nets impossible. No sooner were the nets put out when they were attacked and destroyed by enormous numbers of these crabs. Until then the sunk or mesh net was one of the main methods of fishing; it is not now used except occasionally during flood periods. The presence of this crab in such numbers almost certainly has resulted from the increased salinity of the lakes making conditions suitable for them, and the lack of natural controls or opposition has permitted their increase to such an extent that they are now a serious pest.

From about 1920 onwards the fishery has deteriorated. For instance, the marketed quantity of Bream for the year 1919 was more than 700,000 lb.; in 1929 it was 50,000 lb., a drop of approximately 93 per cent. in ten years. The highest figure since 1919 is 250,000 lb. in 1935, a drop of 64 per cent. To attribute this marked decrease to the depredation of Cormorants is merely to avoid the issue. A reference to the graphs will show that the Ludrick, which is completely dependent on vegetation as food, has been so reduced as to be non-existent from the commercial viewpoint. Another significant fact is that the Gippsland Perch was netted in the lakes and marketed as commonly as Black Bream in the early years. To-day it is practically absent from the lakes; a very few are obtained occasionally after floods. The explanation is that the Perch

is essentially a fresh-water fish. Furthermore, in a few similar though smaller inlets to the east of the Gippsland Lakes there has been no downward trend in the annual quantities of Bream and other species obtained. This is shown on the accompanying graphs. At these inlets the natural bars to the entrances have not been interfered with, and the result is there is no

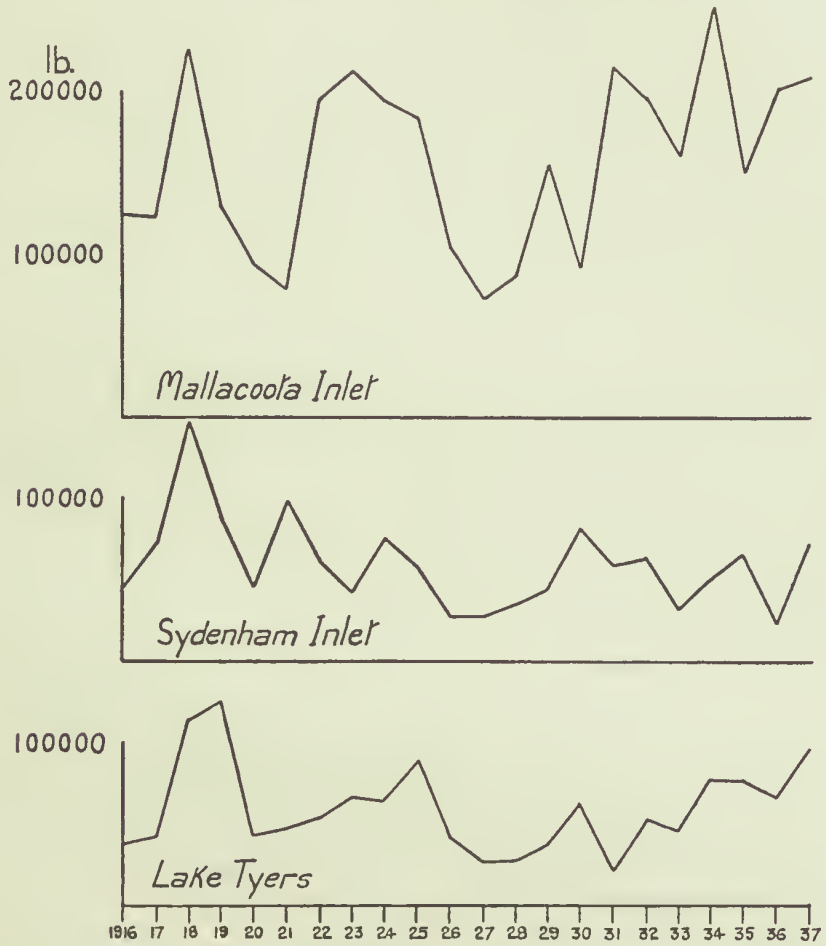


FIG. 15.
Fishes marketed annually from three East Gippsland inlets, 1916-1937; total quantities.

crab pest and aquatic plants still flourish, thus affording food, food harbourage, and probably suitable spawning areas for the fishes.

The fact that the productiveness of these inlets is unimpaired effectively refutes the suggestion that fishermen's nets have destroyed the aquatic grasses in the main lakes; the other

popular idea, that the crabs are responsible, may be safely set aside.

The possibility of over fishing and the increased facility of movement afforded by motor boats have been suggested as contributing factors, but the evidence does not support this. While the use of the motor boat has aided the fisherman it has also added to his expenses, and it should be noted that the number of men engaged went down by about 25 per cent. during the ten years prior to 1937. This reduction in numbers followed the marked diminution in fish quantities which coincided with, and appears to have resulted from, the increased salinity over a period, causing the destruction of the aquatic grasses and the advent of the crab pest in the lakes. A fisherman must obtain a licence for himself and his boat each year, and there are regulations to which he must adhere, notably the prohibition of netting in rivers and specified areas at the mouths of rivers. These points are mentioned as evidence that proper control is exercised over those engaged in the fishery.

Other factors, such as the unnecessary clearing of land, uneconomic settlement generally, and the destruction of forests in the watershed by fires and other means leading to increased erosion, doubtless have contributed to the deterioration of the fishery, but the evidence available appears to me to indicate that the basic cause of the difficulties affecting the Gippsland Lakes Fishery is the permanent artificial entrance. If this entrance was used for the benefit of some other industry there would perhaps be a case to answer, although I am doubtful if any other industry could compete in value with a good estuarine fishery which only requires intelligent working to be permanent and constant in supply.

I have endeavoured to show that neither the Cormorant nor any other particular organism (aside from man) is responsible for what is taking place in the Gippsland Lakes. The Cormorant and every other group or kind of organism (animal and plant), from the microscopical to the largest, are essential parts of a whole. Under natural conditions all of these so fit in and react one with another that, no matter what the climatic or other conditions may be, equilibrium—a natural balance—is maintained. But let any one or any body of people interfere to destroy any single unit of this whole, and the result is likely to be disastrous. This result may be long delayed, but it is none the less certain. It cannot be otherwise, for the natural laws which govern these associations of animals and plants are immutable. There is ample evidence of this destructive interference throughout Victoria alone,

and so long as we continue in our ways, tinkering occasionally with effects instead of dealing with causes, so long will we continue to reap disaster for ourselves and those who follow. There is only one way out and that is to seek to know intimately these natural conditions or laws, and to work with, not against them. This information can be obtained only by means of thorough ecological surveys the cost of which would be equal to an infinitesimal portion of what is at present lost annually through a lack of such work.

NEW SPECIES OF TERTIARY MOLLUSCA FROM VICTORIA.

By the Rev. E. H. Chapple.

Plate XIV.

The type specimens of the Tertiary mollusca described below are in the National Museum, Melbourne. All were collected by the present author.

I have to thank Mr. C. W. Brazenor for the excellent photographs used in Plate XIV.

Family **FISSURELLIDAE**

Genus TUGALIA Gray (e.m.).

Tugalia elata, sp. nov.

Plate XIV, Fig. 8, 8a.

Shell narrowly elongate, convex, back elevated, sides parallel. Protoconch somewhat worn, submarginal, less than one-fifth of length from posterior end; from which a steep descent is made to the margin; the anterior slope from the protoconch is very gradual for two-thirds of the length; radial ribs numerous, rather coarse, with finer ones in the interstices; the radials are crossed by coarse concentric cords passing obliquely around the shell, somewhat nodular at the points of intersection, and enclosing deep irregularly-shaped pits; sides parallel, regularly rounded behind, more narrowly so in front. Base slightly arched, margin weakly denticulated; anal sinus broad and shallow. Owing to the shell being somewhat worn, the sculptural features are not so pronounced as they otherwise would be.

Dimensions.—Holotype. Length, 22 mm.; breadth, 12 mm.; height, 8 mm.

Observations.—This fossil has distinctive features different from any other Australian described species, either recent or fossil. The nearest approach is the New Zealand fossil *Tugali navicula* described by Finlay, but our form differs from it in its greater altitude relatively to the size of the shell. Finlay's species is "rather depressed," whereas ours is elevated.

Locality.—Cement Works, Railway Tunnel, Lower Moorabool River.

Geological Horizon.—Barwonian.

Holotype.—No. 14092.

Family **CYMATIIDAE**

Genus AUSTROTRITON Cossmann.

Austrotriton balcombensis, sp. nov.

Plate XIV, Fig. 5.

Shell ovate, body whorl ventricose, a short conical spire. Apex of protoconch eroded in all examples of this species examined by the author, but

anterior portion spirally lirate. Spire whorls three, exclusive of the protoconch, protuberant and slightly angled a little above the anterior suture; whorls spirally finely lirate, about ten on the penultimate, and rendered granulose by the intercrossing of numerous fine axial threads; a small spiral in the interspaces. Body whorl similarly sculptured. Varices four; no intervariceal nodulations, but the space is occupied by about six feeble axial costae, more pronounced in some examples than in others. Body whorl abruptly descending to the base. Aperture ovate; columella strongly arched, furnished with tooth-like ridges, varying in size, for its whole length; outer lip with about fifteen strong, close-set denticulations within. Canal very short, bent, and reverted.

Dimensions.—Holotype. Length, 15 mm.; breadth, 9 mm.; length of aperture and canal, 9 mm.

Observations.—This species bears considerable resemblance in outline to *Lampusia ovoidea* Tate, of the younger beds at Muddy Creek, but differs in the absence of intervariceal nodulations, the sculpture is less coarse, and the denticulations within the outer lip and the tooth-like ridges on the columella are both coarser and more numerous. This species may be the ancestor of the younger fossil. The absence of the apex in the several examples examined is suggestive in the light of Finlay's remarks relative to *Austrotriton* (Transactions of N.Z. Institute, vol. 62, p. 8), wherein he speaks of the "initial whorl as quite irregular in shape, roughened and markedly differentiated in texture from the polished succeeding whorl . . . the whole appearance is that of a scar left by the loss of some integral part."

Locality.—Grice's Creek, near Mornington.

Geological Horizon.—Balcombian.

Holotype.—No. 14093.

Family **TURRIDAE**

Genus ETREMA Hedley.

Etrema turrita, sp. nov.

Plate XIV, Fig. 3.

Shell small, fusiform, turreted, solid; protoconch of two smooth convex whorls; adult whorls five, sharply angulate; anterior two-thirds of spire whorls vertical whilst the posterior is flattened, almost at right angles to each other; the posterior is not lirate; the anterior is crossed by numerous fine, oblique, axial riblets. The posterior whorls show one distinct spiral on the front, the antepenultimate two, and the penultimate whorl a suspicion of a third on some examples; the spirals cross the riblets and are rather acute; they are situated on the lower half of the whorl near the anterior suture; where they cross the axial riblets they are somewhat granulate. On the periphery of the body whorl there are four or five spirals; they are continued on the base and the canal but are finer and closer. The shell is sharply contracted at the base, the outer lip strongly inflected, and swollen behind; sinus deeply incised, U-shaped, and effuse exteriorly; aperture narrowly ovate; columella nearly straight, smooth; canal short, a little effuse anteriorly.

Dimensions.—Holotype. Length, 6·5 mm.; breadth, 2·25 mm.

Observations.—This species bears some resemblance to *Etrema pseudo-*

elegans Chapman, but the whorls are not rounded anteriorly as in that species, the riblets are much finer, more oblique, and the spirals less numerous.

Locality.—Spoil heap at brown coal mine, Altona; several examples.

Geological Horizon.—Balcombian.

Holotype.—No. 14094. Paratype.—No. 14095.

Genus FILODRILLIA Hedley.

Filodrillia turrita, sp. nov.

Plate XIV, Fig. 4.

Shell fusiform, turreted. Protoconch with two small, smooth, convex whorls, the initial portion oblique, the anterior half of second whorl costated. Adult whorls seven, of regular increase; earlier whorls acutely angular with a series of coarse, blunt tubercles on the angulation; later whorls angulated, almost right-angled at the periphery; the keel consists of two close-set granulose lirae; the anterior half of the whorl, which is a little contracted at the suture, carries three granulose lirae on the penultimate, with a very fine line in the interspaces; the posterior half is flattened, and bears two or three fine spiral lines; the suture is marginate. The body whorl is acutely angled, and similarly ornamented in front with coarse and fine lirae alternating which extend to the extremity of the canal. The whole shell is crossed axially by close-set, regular growth lines, oblique on the anterior portion of the whorls, and crescentric on the fasciole, thus outlining the shape of the sinus. The intersection of transverse and spiral lines gives the shell a granulose, network appearance. Aperture oval, slightly angled at the periphery of the whorl, and contracted at the anterior; outer lip thin, lirate within; sinus wide and moderately deep; columella excavated; canal short and open, a little bent.

Dimensions.—Holotype. Length, 15 mm.; breadth, 5 mm.; length of aperture and canal, 6 mm.

Observations.—This fossil is classed as *Drillia* sp. in the Dennant Collection at the National Museum, and is fairly common at Balcombe Bay, Grice's Creek, Muddy Creek, and Lower Moorabool, in addition to Altona. It appears to have no close affinity with any other described species, recent or fossil. It has some features in common with the recent *F. stadialis* Hedley, and *F. steira* Hedley, but they are not sufficiently close to cause confusion with those species.

Locality.—Spoil heap at brown coal mine, Altona, near Williamstown.

Geological Horizon.—Balcombian.

Holotype.—No. 14096.

Genus MITRITHARA Hedley.

Mitrithara megale, sp. nov.

Plate XIV, Fig. 2.

Shell large for the genus, thin, cylindro-fusiform. Protoconch of two small, smooth, convex whorls, the earlier one the larger and slightly projecting. Adult whorls six, a little convex and slightly shouldered at the posterior suture, the latter well impressed. The whorls are spirally lirate throughout, about ten rounded spirals on the penultimate whorl, and about twenty-six

on the body whorl, the interspaces somewhat wider. The lirae are smaller and more crowded on the periphery, but descending to the base and the canal they are stouter and more widely spaced. The whorls are crossed obliquely by delicate and close-set riblets which produce granules at the points of intersection with the spirals. The riblets fade out at the base of the body whorl. Aperture narrow; sinus a slight flexure; outer lip thin (slightly damaged), a little incurved posteriorly; columella with two small, rounded plications about midway between the mouth and the posterior angle; canal short and well open.

Dimensions.—Holotype. Length, 14 mm.; breadth, 6 mm.; length of aperture and canal, 8 mm.

Observations.—This species bears some resemblance to the recent *Mitrithara columnaria* Hedley, but the fossil does not possess the strong cord and sulcus at the summit of the whorls such as found in the recent species. It also differs in possessing radial riblets which are absent in *M. columnaria.* In this respect the fossil approaches the recent *Mitrithara proles* Hedley, but in the latter case the radials are not so continuous, and they are curved rather than oblique. The spacing of the spiral lirae is also different. *M. megale* approximates closely to *Mitromorpha daphnelloides* T. Woods, but the former is a much larger species, and it does not possess the "broad, wide, groove-like space below the suture which is margined." The outer lip of *M. daphnelloides* is lirate within, whereas in our species it is smooth.

Locality.—Beach Cliffs, 2½ miles west of the Gellibrand River. Collected by the author.

Geological Horizon.—Barwonian.

Holotype.—No. 14097. Paratype.—No. 14098.

Family **MURICIDAE**

Genus TROPHON MONTFORT.

Subgenus ENATIMENE Iredale.

Trophon (Enatimene) makros, sp. nov.

Plate XIV, Fig. 6.

Shell narrowly fusiform; whorls convex, a little shouldered in the posterior-third. Protoconch with one-and-a-half convex whorls, the apex flattened, the anterior half transversely costate. Adult whorls five and a half, the posterior ones crossed by axial costae producing nodulations on the periphery. On the penultimate and body whorl the axials are faint and narrow, about eleven on the penultimate, with the interspaces striate. The whorls are spirally lirate, the lirae rounded, and slightly nodulate at the intersection with the costae; about six principal lirae on the penultimate, with finer ones in the interspaces. The body whorl is similarly sculptured, about twelve main spirals, narrower than the shallow interspaces; sutures well impressed, undulating. Aperture oval, acutely angulated at the posterior, and abruptly contracted at the anterior; outer lip swollen a little distance from the margin externally, and lirate within, margin thin; columella excavated; inner lip continuous with the outer; canal of medium length, narrow, oblique, and reverted.

Dimensions.—Holotype. Length, 13·5 mm.; breadth, 5·5 mm.; length of aperture and canal, 7 mm.

Observations.—This species differs from *T. crassiliratus* (described below) in being narrower and more elongate in shape, the sculpture is very much finer, having numerous axial striae, and fine spirals in the interspaces, and the canal is longer. A near ally in general appearance is *T. molorthus* Hedley, but the protoconch is less acute than in the recent species, the radial ribs not so bold, and the spirals less numerous. It is also longer in proportion to its breadth.

Locality.—Princetown; same locality as *T. (E.) crassiliratus* q.v.

Geological Horizon.—Balcombian.

Holotype.—No. 14099.

Trophon (Enatimene) crassiliratus, sp. nov.

Plate XIV, Fig. 7.

Shell narrowly ovate, thick, solid. Protoconch of one-and-a-half smooth, convex whorls. The spire consists of four convex whorls with an impressed suture which is a little channelled; spiral lirae bold, acutely rounded, six on the penultimate whorl, narrower than the interspaces; spiral striae absent. Body whorl convex, with about twelve well spaced, rounded lirae. Axially, the whorls are ornamented with narrow, not very conspicuous costae, narrower than the interspaces, and tuberculate where they are crossed by the spirals, axial lines in the interspaces; there are about fifteen costae on the penultimate whorl; they fade away towards the base of the body whorl. Aperture narrowly ovate, oblique, posterior acutely angled; peristome continuous; outer lip thickened, faintly variced, and lirate within, a small callus at the anterior end; columella arched; canal short, oblique, a little reverted.

Dimensions.—Holotype. Length, 11 mm.; breadth, 5·5 mm.; length of aperture and canal, 6 mm.

Observations.—The author has not been able to discover any described species, either recent or fossil, that bears any close affinity to the one under consideration.

Locality.—Land-slide, about three-quarters of a mile west of the Gellibrand River, and about the same distance from the beach. Princetown district. A number of examples collected.

Geological Horizon.—Barwonian.

Holotype.—No. 14100. Paratype.—No. 14101.

Family **ARCHITECTONICIDAE**

Genus ARCHITECTONICA Roeding.

Subgenus Discotectonica Marwick.

Architectonica (Discotectonica) squamogranosa, sp. nov.

Plate XIV, Fig. 1, 1a.

Shell discoidal. Protoconch of one turn, smooth, well defined. Adult whorls four, slightly convex; suture incised; periphery acutely keeled. The upper surface of each whorl is divided by four spiral lines, the central two

rather weak; the whorls are crossed obliquely by numerous close-set radial grooves, the result of the intersection of spiral lines and radial grooves being a series of elongate, flattish, bead-like granules. On the last whorl the spiral lines become very faint whereas the radial grooves persist to the periphery; a shallow spiral groove occurs on the last whorl just below the suture, and another close to the keel. The base is slightly convex, a conspicuous rounded cord encircles the base near the keel, with a faint thread in the intervening space. A deeply incised spiral groove limits the umbilical border. The latter is crossed by strong radial grooves giving rise to a series of rhomb-like structures which extend within the umbilicus. The outer edge of the incised spiral is also divided by radial grooves rather weaker, not corresponding to the inner ones, and extending well across the base. The umbilicus is wide and deep.

Dimensions.—Holotype. Height, 8 mm.; breadth, 19 mm.

Observations.—This species resembles *Solarium acutum* T. Woods, in many of its features, but its spiral lineations are less granulose, also the character of the sculpture on the base is different. Instead of seven rows of spiral granulations as in *S. acutum,* our species has only one, that immediately surrounding the umbilicus, the remainder of the base being comparatively smooth. Its nearest ally is the New Zealand fossil *Architectonica (Discotectonica) seniscula* Marwick. In addition to that collected by the author, examples of the same species are contained in the Dennant Collection in the National Museum bearing Tate's MS. name, *Architectonica squamogranosa,* but undescribed. The author has adopted Tate's specific name.

Locality.—Muddy Creek, lower beds.

Geological Horizon.—Balcombian.

Holotype.—No. 14102.

Plate XIV.

Photographs of Holotypes.

Fig. 1. Architectonica (Discotectonica) squamogranosa, sp. nov., × 2 diam.
Fig. 2. Mitrithara megale, sp. nov., × 3 diam.
Fig. 3. Etrema turrita, sp. nov., × 6 diam.
Fig. 4. Filodrillia turrita, sp. nov., × 3 diam.
Fig. 5. Austrotriton balcombensis, sp. nov., × 3 diam.
Fig. 6. Trophon (Enatimene) makros, sp. nov., × 3 diam.
Fig. 7. Trophon (Enatimene) crassiliratus, sp. nov., × 4 diam.
Fig. 8. Tugalia elata, sp. nov., × 2 diam.

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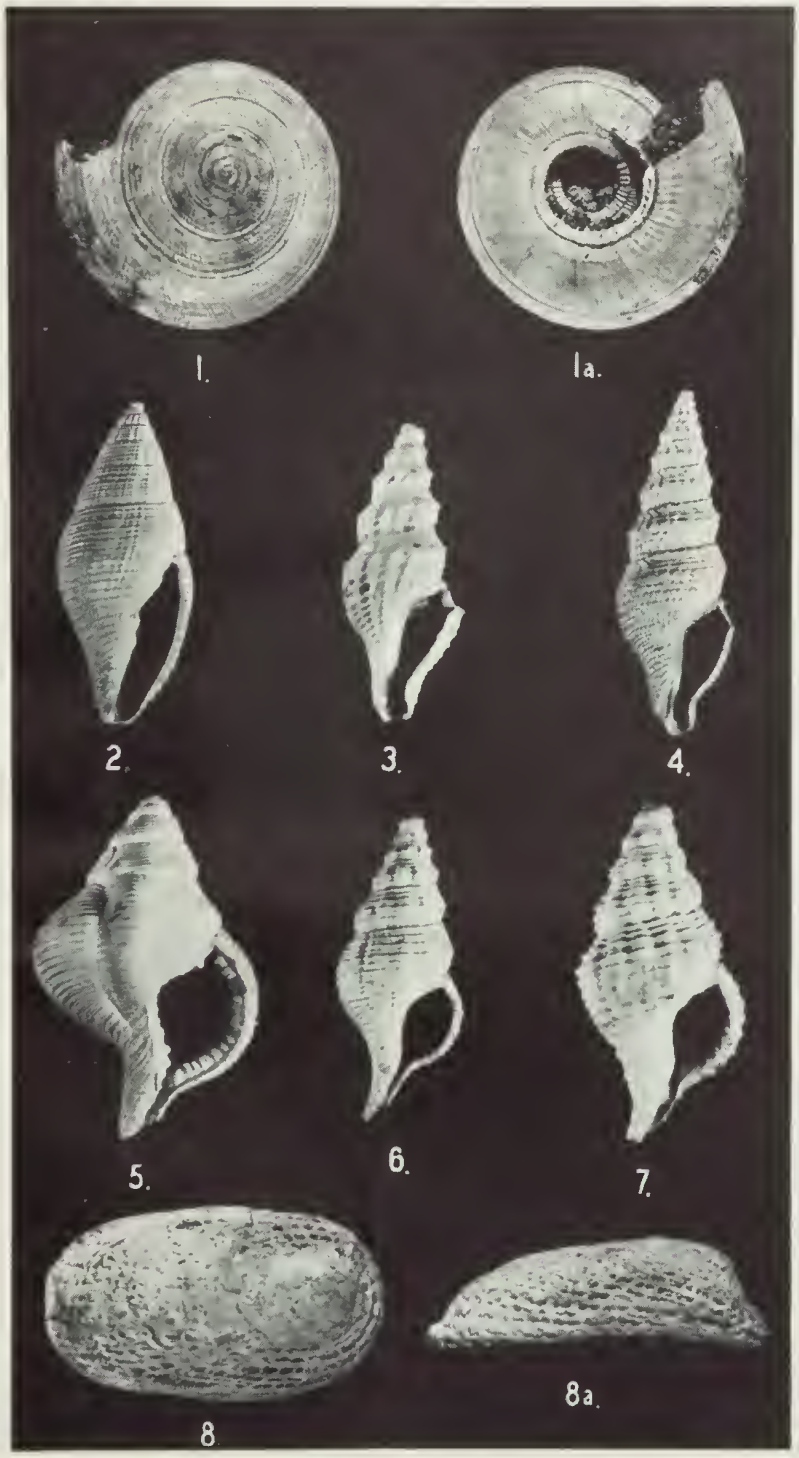

Tertiary Mallusca; new species